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ZED-F9P

u-blox F9 high precision GNSS module

Integration Manual

Abstract

This document describes the features and specifications of ZED-F9P; a multi-band GNSS module offering centimeter level accuracy with integrated RTK.

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Document Information

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This document applies to the following products:

Product name	Type number	Firmware version	PCN reference
ZED-F9P	ZED-F9P-00B-00	HPG 1.00B03	N/A

Contents

1 Overview

The ZED-F9P positioning module features the new u-blox F9 receiver platform, which provides multi-band GNSS to high volume industrial applications in a compact form factor. The module enables precise navigation and automation of moving machinery in industrial and consumer grade products in a small surface mounted form factor.

The ZED-F9P is a multi-band GNSS module offering centimeter-level accuracy with integrated RTK. Following u-blox's proven strategy of bringing high-performance GNSS technology to mass markets, the ZED-F9P incorporates u-blox's new F9 multi-band platform in a tiny SMD form-factor of only 17.0 x 22.0 x 2.4 mm.

1.1 Real Time Kinematic

u-blox ZED-F9P takes GNSS precision to the next level:

- Delivers accuracy down to the centimeter-level: 0.01m + 1 ppm CEP
- Fast time to first fix and robust performance with multi-band, multi-constellation reception
- Compatible with leading correction services for global coverage and versatility

Some typical applications for the ZED-F9P are shown below:

Figure 1: Typical applications for the ZED-F9P

1.1.1 RTK modes of operation

The ZED-F9P supports two modes of operation:

1. ZED-F9P operating as a base: providing RTCM3 corrections to a ZED-F9P rover, or a network of ZED-F9P rovers. To configure a ZED-F9P as a base see section Base configuration.
2. ZED-F9P operating as a rover: receiving RTCM3 corrections from a ZED-F9P operating as a base, or receiving RTCM3 corrections from a Network RTK system, or a satellite link providing corrections. To configure a ZED-F9P as a rover see section Rover configuration.

1.2 Typical ZED-F9P application setups

1.2.1 ZED-F9P in a drone application

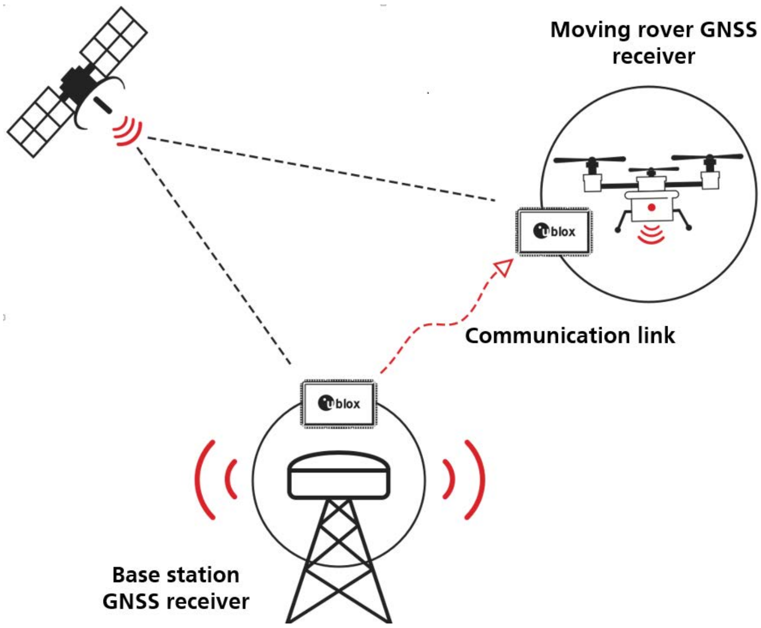


Figure 2: ZED-F9P base and rover in a short baseline drone application

1.2.2 ZED-F9P in a robotic mower application

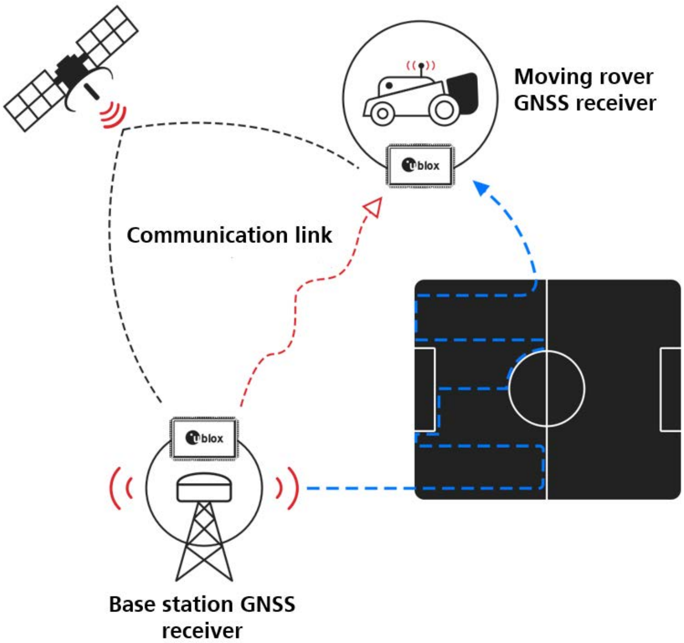


Figure 3: ZED-F9P base and rover in a short baseline robotic mower application

1.3 Default GNSS configuration

The default GNSS configuration is:

- GPS L1C/A L2C

- GLO L1OF L2OF
- GAL E1B/C E5b
- BDS B1I
- QZSS L1C/A L2C

BDS B2I is also supported but not enabled in the default GNSS configuration

The configuration settings can be modified using UBX protocol configuration messages, see the ZED-F9P Interface Description [2].

1.4 RTCM3 corrections

The ZED-F9P high precision receiver needs to receive RTCM3 corrections to function as an RTK rover, and the RTCM3 messages it receives must be for all the GNSS constellations and signals being received. The ZED-F9P high precision receiver needs to output RTCM3 corrections if being used as an RTK base. The correct RTCM3 messages must also be selected for the GNSS constellations and signals being received. The supported input and output messages are listed in the following sections.

For rover configuration with default GNSS configuration the recommended list of RTCM3 input messages are:

- RTCM 1005
- RTCM 1077
- RTCM 1087
- RTCM 1097
- RTCM 1127
- RTCM 1230

For base configuration with default GNSS configuration the recommended list of RTCM3 output messages are:

- RTCM 1005
- RTCM 1077
- RTCM 1087
- RTCM 1097
- RTCM 1127
- RTCM 1230

The RTCM3 specification is currently at V3.3 and it must be noted that RTCM2x messages are not supported by the RTCM3 standard.

You can download the standard from the RTCM website http://www.rtcm.org/differential-global-navigation-satellite--dgnss--standards.html

To modify the RTCM input/output settings see Section Configuration and the u-blox ZED-F9P Interface Description [2].

1.5 Supported list of RTCM3 input messages

Message	Description
RTCM 1001	L1-only GPS RTK observables
RTCM 1002	Extended L1-only GPS RTK observables
RTCM 1003	L1/L2 GPS RTK observables
RTCM 1004	Extended L1/L2 GPS RTK observables
RTCM 1005	Stationary RTK reference station ARP

Message	Description
RTCM 1006	Stationary RTK reference station ARP with antenna height
RTCM 1007	Antenna descriptor
RTCM 1009	L1-only GLONASS RTK observables
RTCM 1010	Extended L1-only GLONASS RTK observables
RTCM 1011	L1/L2 GLONASS RTK observables
RTCM 1012	Extended L1/L2 GLONASS RTK observables
RTCM 1074	GPS MSM4
RTCM 1075	GPS MSM5
RTCM 1077	GPS MSM7
RTCM 1084	GLONASS MSM4
RTCM 1085	GLONASS MSM5
RTCM 1087	GLONASS MSM7
RTCM 1094	Galileo MSM4
RTCM 1095	Galileo MSM5
RTCM 1097	Galileo MSM7
RTCM 1124	BeiDou MSM4
RTCM 1125	BeiDou MSM5
RTCM 1127	BeiDou MSM7
RTCM 1230	GLONASS code-phase biases

Table 1: ZED-F9P supported input RTCM 3.3 messages

1.6 Supported list of RTCM3 output messages

Message	Description
RTCM 1005	Stationary RTK reference station ARP
RTCM 1077	GPS MSM7
RTCM 1087	GLONASS MSM7
RTCM 1097	Galileo MSM7
RTCM 1127	BeiDou MSM7
RTCM 1230	GLONASS code-phase biases

Table 2: ZED-F9P supported output RTCM 3.3 messages

1.7 NTRIP - Networked Transport of RTCM via Internet Protocol

Networked Transport of RTCM via Internet Protocol, or NTRIP, is a protocol developed by the Federal Agency for Cartography and Geodesy of Germany (BKG) that enables streaming of DGPS or RTK correction data via the internet.

There are three major parts to the NTRIP system: The NTRIP client, the NTRIP server, and the NTRIP caster:

1. The NTRIP server is a PC or on-board computer running NTRIP server software communicating directly with a GNSS reference station. The NTRIP server serves as the intermediary between the GNSS receiver (NTRIP Source) streaming RTCM data and the NTRIP caster.
2. The NTRIP caster is a HTTP server which receives streaming RTCM data from one or more NTRIP servers and in turn streams the RTCM data to one or more NTRIP clients via the internet.
3. The NTRIP client receives streaming RTMC data from the NTRIP caster to apply as real-time corrections to a roving GNSS receiver.

The relevant RTCM standard NTRIP V2 can be downloaded from the RTCM standards website: http://www.rtcm.org/differential-global-navigation-satellite--dgnss--standards.html

1.8 Virtual Reference Station

☞ In order for VRS to work the VRS Caster needs to know the location of the Rover receiver. To do this the Rover has to output the NMEA GGA message and this has to be sent to the VRS Caster. Typically only the NMEA GGA message is needed.

Reaching centimeter-level accuracy of positioning typically requires use of precise dual-frequency carrier phase observations. Furthermore, these observations are usually processed using a differential GNSS (DGNSS) algorithm, such as real time kinematic (RTK) or post-processing (PP). Regardless of the specific differential algorithm, however, implicit in the process is an assumption that the quality of the reference station data is consistent with the desired level of positioning accuracy. The virtual reference station (VRS) concept can help to satisfy this requirement using a network of reference stations. As a quick review, a typical DGNSS setup consists of a single reference station from which the raw data (or corrections) are sent to the rover receiver (i.e., the user). The user then forms the carrier phase differences (or corrects their raw data) and performs the data processing using the differential corrections. In contrast, GNSS network architectures often make use of multiple reference stations. This approach allows a more precise modeling of distance-dependent systematic errors principally caused by ionospheric and tropospheric refractions, and satellite orbit errors. More specifically, a GNSS network decreases the dependence of the error budget on the distance of nearest antenna. The picture below shows the network of reference stations used to build up a service covering the whole of Switzerland.

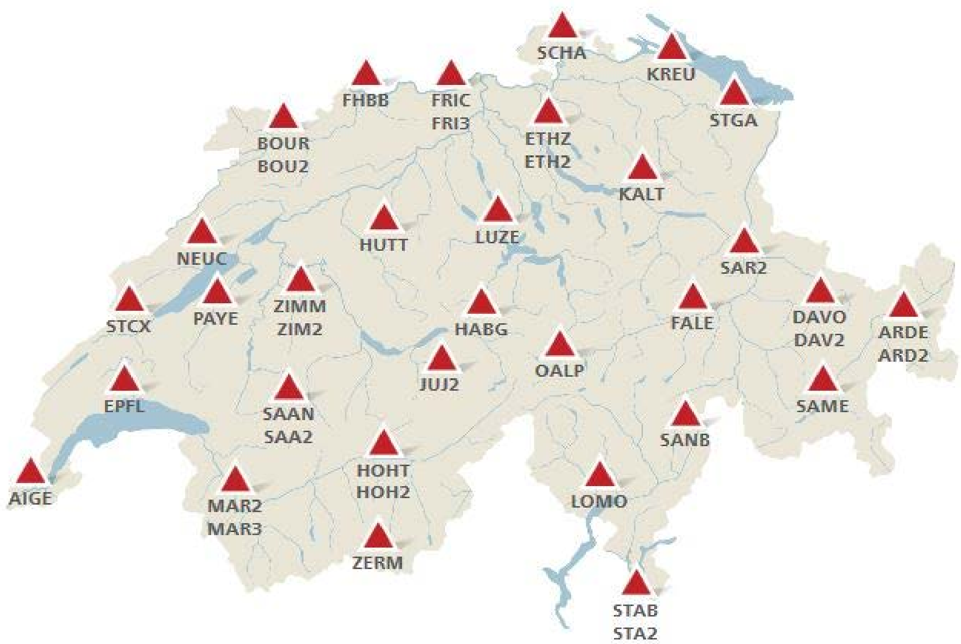


Figure 4: VRS network in Switzerland

The network of receivers is linked to a computation center, and each station contributes its raw data to help create network-wide models of the distance-dependent errors. The computation of errors based on the full network's carrier phase measurements involves, first of all, the resolution of carrier phase ambiguities and requires knowledge of the reference station positions. (The latter is usually determined as part of the network setup.)

This generated VRS data is then sent to the user through a wireless connection, often using the Networked Transport of RTCM via Internet Protocol (NTRIP). Finally, just as if the VRS data had come from a physical reference station, the rover receiver uses standard single-baseline algorithms to determine the coordinates of the user's receiver, in near-real-time kinematic or post-processed modes. The main purpose of a VRS station is to reduce the baseline distance between the rover and the reference station in order to efficiently remove spatially correlated errors using differential processing, and to incorporate error corrections obtained from the reference stations network. The Rover receiver must send its own actual position back typically using the NMEA GGA message. Usually if the VRS system does not receive a GGA message it will not provide the RTCM3 data to the Rover. he VRS concept allows a less dense antenna network without accuracy degradation because the multiple reference station network better models the spatially correlated GNSS errors over longer baselines. As a result the maximum distance between the rover and the nearest reference station can be extended beyond the typical 10 ~15 kilometers without accuracy degradation of the single reference station case. Another benefit of a VRS is that the reference data are free of site-specific errors such as multipath, because the VRS computation assumes that the virtual station is situated at an ideal location.

1.9 Configuration

The configuration settings can be modified using UBX protocol configuration messages, see the Receiver Configuration and CFG Interface sections in the ZED-F9P Interface Description [2]. If stored in RAM the modified settings remain effective until power-down or reset. If these settings have been stored in BBR (Battery Backed RAM), then the modified configuration will be retained, as long as the backup battery supply is not interrupted. The configuration can be saved permanently in flash memory. The new messages that should be used are the UBX-CFG-VALSET, UBX-CFG-VALGET, and UBX-CFG-VALDEL messages and are supported on the early Beta firmware. Please see the u-blox ZED-F9P Interface Description [2].

☞ u-center 18.05 or newer has support for the UBX-CFG-VALSET, UBX-CFG-VALGET and UBX-CFG-VALDEL messages.

☞ The early Beta firmware for the ZED-F9P still accepts the legacy UBX-CFG messages, however these messages are now deprecated on ZED-F9P and have been replaced by new configuration messages that should be used instead of the older UBX-CFG messages.

1.9.1 Communication interface configuration

It is possible to configure the communication interfaces of a base station or a rover. This is done by setting the appropriate configuration items by using the UBX-CFG-VALSET message. Several configuration items allow configuring the operation modes of the different communications interfaces. This includes parameters for the data framing, transfer rate and protocols used. A subset of the relevant configuration items is seen below for the UART1 only. For all for available configuration items, see ZED-F9P Interface Description [2].

Configuration item	Description
CFG-UART1-BAUDRATE	The baud rate that should be configured on the UART1
CFG-UART1INPROT-UBX	Flag to indicate if UBX should be an input protocol on UART1
CFG-UART1INPROT-NMEA	Flag to indicate if NMEA should be an input protocol on UART1
CFG-UART1INPROT-RTCM3X	Flag to indicate if RTCM3X should be an input protocol on UART1
CFG-UART1OUTPROT-UBX	Flag to indicate if UBX should be an output protocol on UART1
CFG-UART1OUTPROT-NMEA	Flag to indicate if NMEA should be an output protocol on UART1
CFG-UART1OUTPROT-RTCM3X	Flag to indicate if RTCM3X should be an output protocol on UART1

Table 3: Typical configuration items used for UART1 baudrate and protocol configuration

☞ The default communication configuration of the UART1 port is set at a baud rate of 38400 baud with NMEA messages being output. The module will respond to incoming UBX binary commands. To see all the default configuration of ZED-F9P, please see the u-blox ZED-F9P Interface Description [2].

☞ If the navigation rate of the rover is increased, the UART baud rate should be increased to account for the additional data that is going to be transferred. A baud rate of 460800 baud is recommended for high update rates with the minimum required messages enabled.

☞ The default baud rate of 38400 baud should be increased to allow for increased capacity over the UART interface if UBX messages, RAW data or debug messages are enabled, again a baud rate of 230400 baud to 460800 baud is recommended in this case.

1.9.2 Message output configuration

It is possible to configure the rate of NMEA, UBX and RTCM protocol output messages of a base station or a rover. If the rate configuration value is zero, the corresponding message will not be output. Values greater than zero indicate how often the message is output. Note that all message output is additionally subject to the protocol configuration of the communication interfaces. Messages of a given protocol will not be output until the protocol is enabled for output on the interface.

Setting the appropriate configuration items is done by using the UBX-CFG-VALSET message. Several configuration items allow configuring the message output rates per message and per communication interface. For all for available configuration items, see the CFG-MSGOUT configuration group in ZED-F9P Interface Description [2].

1.9.3 Base station: RTCM3 output configuration

To enable a base station to output the recommended RTCM messages, the relevant configuration items need to be set using the UBX-CFG-VALSET message. Below are the relevant configuration items for the UART1 interface:

Configuration item	Description
CFG-MSGOUT-RTCM_3X_TYPE1005_UART1	Output rate of the RTCM-3X-TYPE1005 message on port UART1
CFG-MSGOUT-RTCM_3X_TYPE1077_UART1	Output rate of the RTCM-3X-TYPE1077 message on port UART1
CFG-MSGOUT-RTCM_3X_TYPE1087_UART1	Output rate of the RTCM-3X-TYPE1087 message on port UART1
CFG-MSGOUT-RTCM_3X_TYPE1097_UART1	Output rate of the RTCM-3X-TYPE1097 message on port UART1
CFG-MSGOUT-RTCM_3X_TYPE1127_UART1	Output rate of the RTCM-3X-TYPE1127 message on port UART1
CFG-MSGOUT-RTCM_3X_TYPE1230_UART1	Output rate of the RTCM-3X-TYPE1230 message on port UART1

Table 4: Configuration items used for typical RTCM output configuration on UART1

1.9.4 Base and rover: UBX output configuration

To enable a base or rover to output the recommended UBX messages, the relevant configuration items need to be set using the UBX-CFG-VALSET message. Below are the relevant configuration items for the UART1 interface:

Configuration item	Description
CFG-MSGOUT-UBX_NAV_SAT_UART1	Output rate of the UBX-NAV-SAT message on port UART1

Configuration item	Description
CFG-MSGOUT-UBX_NAV_SIG_UART1	Output rate of the UBX-NAV-SIG message on port UART1
CFG-MSGOUT-UBX_NAV_SOL_UART1	Output rate of the UBX-NAV-SOL message on port UART1
CFG-MSGOUT-UBX_NAV_POSLLH_UART1	Output rate of the UBX-NAV-POSLLH message on port UART1
CFG-MSGOUT-UBX_NAV_PVT_UART1	Output rate of the UBX-NAV-PVT message on port UART1
CFG-MSGOUT-UBX_NAV_RELPOSNED_UART1	Output rate of the UBX-NAV-RELPOSNED message on port UART1
CFG-MSGOUT-UBX_NAV_STATUS_UART1	Output rate of the UBX-NAV-STATUS message on port UART1
CFG-MSGOUT-UBX_NAV_SVIN_UART1	Output rate of the UBX-NAV-SVIN message on port UART1
CFG-MSGOUT-UBX_RXM_RTCM_UART1	Output rate of the UBX-RXM-RTCM message on port UART1

Table 5: Configuration items used for recommended UBX output configuration on UART1

1.9.5 Base station: Mode configuration

To set a ZED-F9P as a base station it is necessary to set its coordinates. Once this is done, the ZED-F9P will operate as a base station and output the configured stream of RTCM messages.

There are two ways to set the base station coordinates. If the coordinates are not known, it can be set into survey-in mode and the receiver's fix will be calculated. If the coordinates are known, it can be set directly to fixed mode.

To set the base station into the desired mode, the appropriate configuration items must be set by using the UBX-CFG-VALSET message. For all for available configuration items, see the CFG-TMODE configuration group in ZED-F9P Interface Description [2].

To set a base station into survey-in mode (CFG-TMODE-MODE=SURVEY_IN), the relevant configuration items below need to be set:

Configuration item	Description
CFG-TMODE-MODE	Receiver mode (Disabled or Survey in or Fixed)
CFG-TMODE-SVIN_MIN_DUR	Survey-in minimum duration
CFG-TMODE-SVIN_ACC_LIMIT	Survey-in position accuracy limit

Table 6: Configuration items used for setting a base station into survey-in

☞ Both requirements (duration time and accuracy limit) must be met before the base station completes the survey in process. Once this is done then it will begin to output the base position message RTCM 1005. The rover will not be able to enter RTK Fixed mode unless it is receiving RTCM 1005.

To set a base station into fixed mode (CFG-TMODE-MODE=FIXED), the relevant configuration items below need to be set:

Configuration item	Description
CFG-TMODE-MODE	Receiver mode (Disabled or Survey in or Fixed)
CFG-TMODE-POS_TYPE	Determines whether the ARP position is given in ECEF or LAT/LON/HEIGHT
CFG-TMODE-ECEF_X	ECEF X coordinate of the ARP position
CFG-TMODE-ECEF_Y	ECEF Y coordinate of the ARP position
CFG-TMODE-ECEF_Z	ECEF Z coordinate of the ARP position
CFG-TMODE-LAT	Latitude of the ARP position

Configuration item	Description
CFG-TMODE-LON	Longitude of the ARP position
CFG-TMODE-HEIGHT	Height of the ARP position
CFG-TMODE-ECEF_X_HP	High-precision ECEF X coordinate of the ARP position
CFG-TMODE-ECEF_Y_HP	High-precision ECEF Y coordinate of the ARP position
CFG-TMODE-ECEF_Z_HP	High-precision ECEF Z coordinate of the ARP position
CFG-TMODE-LAT_HP	High-precision latitude of the ARP position
CFG-TMODE-LON_HP	High-precision longitude of the ARP position
CFG-TMODE-HEIGHT_HP	High-precision height of the ARP position

Table 7: Configuration items used for setting a base station into fixed mode

☞ The high precision option for each of the position types allows you to enter the value in mm compared to the standard cm value.

☞ Once the receiver is set in Fixed mode you only then have to select what position format you are going to use to enter the base antenna position. Either LLH or ECEF. You then have an option to enter high precision (mm) co-ordinates instead of the standard cm accurate co-ordinates if you know the base antenna location to this sufficient accuracy. You do not need to do both.

For example if CFG-TMODE-POS_TYPE=ECEF. If you only know the base antenna position to an absolute cm level accuracy use CFG-TMODE-ECEF_X, CFG-TMODE-ECEF_Y, CFG-TMODE-ECEF_Z. If you know the absolute accuracy of the base antenna to mm level accuracy then you use CFG-TMODE-ECEF_X_HP, CFG-TMODE-ECEF_Y_HP, CFG-TMODE-ECEF_Z_HP.

The same is true if you use CFG-TMODE-POS_TYPE=LLH.

⚠ **Attention** If the base station is moved, survey-in must be repeated to obtain the new coordinates or the fixed mode must be reconfigured using the new coordinates.

1.9.6 Base station: Configuration procedure overview

☞ This overview describes how to set the base station configuration by using the UBX-CFG-VALSET message view that is available in u-center 18.05 or newer. The UBX-CFG-VALSET message view needs to be set up for the configuration group and configuration keys that you wish to set. Once a configuration key is selected, you need to add it to the list by clicking the 'Add to List' button. Once it is in the 'Configuration changes to send' table you can edit or read the current receiver value. If you click on the Key item in the list, it will then be highlighted and allow you to set the value or read the current set value.

To configure the module for base station operation the following procedure needs to be carried out:

- Set the UART1 interface for the correct host baud rate.
    - Select Group: CFG-UART1, Key name: CFG-UART1-BAUDRATE. Please see Figure 5.
    - Add it to the list and highlight it. It will now give you the option of setting the value or reading the current value. Please see Figure 6.
    - Now add the value, e.g. 230400 baud, into the new Value window that appears below the list. Please see Figure 7.
    - Now set the configuration by clicking the Send button at the bottom of the message tree view. Remember to then set u-center baud rate to match the value you set in the receiver.
- Setting the base station required RTCM3 message output can be done in one session. Select Group CFG-MSGOUT, Key name: CFG-MSGOUT-RTCM3X and select the UART1 required messages. Add each message to the list and then set the value of each to 1. Then click Send. Please see Figure 8.

- We need to enable some UBX messages to view the status of the base station and of the survey-in process. Select Group CFG-MSGOUT, Key name: CFG-MSGOUT-UBX and select the UART1 required messages. Add each message to the list and then set the value of each to 1. Then click Send. Please see Figure 9.
- Set the unit into base station mode by enabling survey-in or Fixed Mode by set items from the CFG-TMODE configuration group. Please see a survey-in example in Figure 10.
- The required settings for survey-in required estimated accuracy and the minimum survey-in time can be set at the same time. A figure of 50000 (0.1 mm x 50000 = 5 m) for estimated accuracy and survey-in time of 60 s is sensible.
- If using the survey-in mode, sensible settings must be selected based on the environment and achievable accuracy in the base location. The base will not typically achieve less than a real 1 m accuracy in good conditions, in obstructed multi-path conditions this figure could be higher and the survey-in time to achieve even the lower accuracy can take longer than expected. The base antenna might need to be moved to a better location or the required accuracy and/or survey-in time might need to be extended. Please verify with the survey-in status using NAV-SVIN message.
- The unit will then output all the messages once it has completed survey-in or once Fixed Mode has been enabled with the required base antenna co-ordinates. Please see Figure 11 to verify all RTCM3 messages are being output. RTCM3 MSG 1005 will **only** be output once survey-in is completed or the Fixed co-ordinates are entered for the base antenna.
- Once the base has either completed survey-in or been set into Fixed mode correctly it will indicate TIME mode in the u-center Data view. Please see in Figure 12.

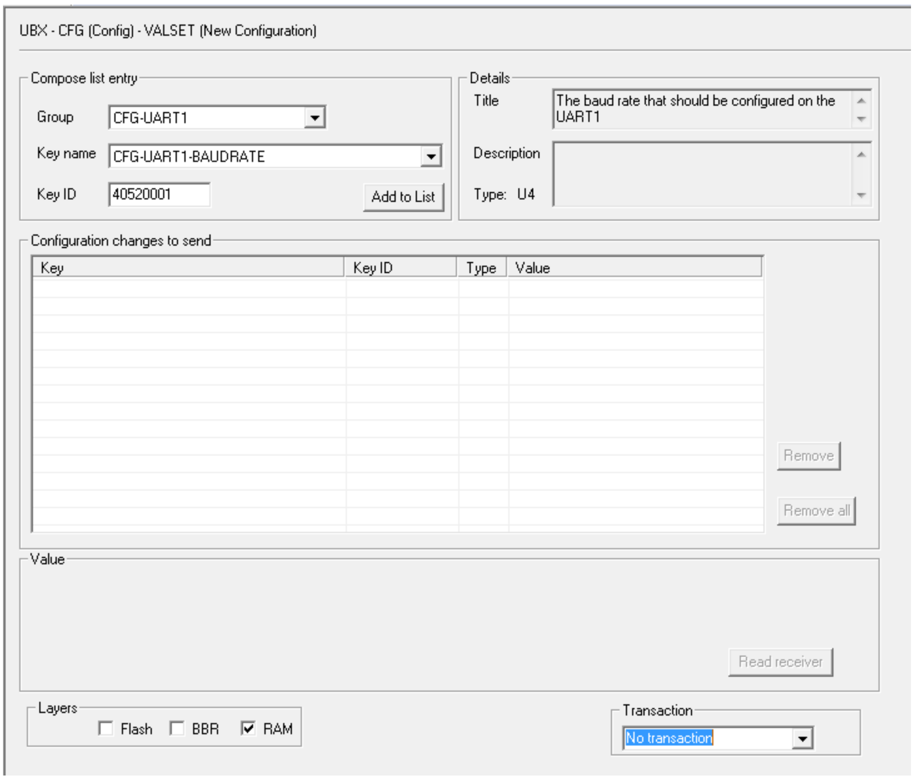


Figure 5: u-center UBX-CFG-VALSET message view

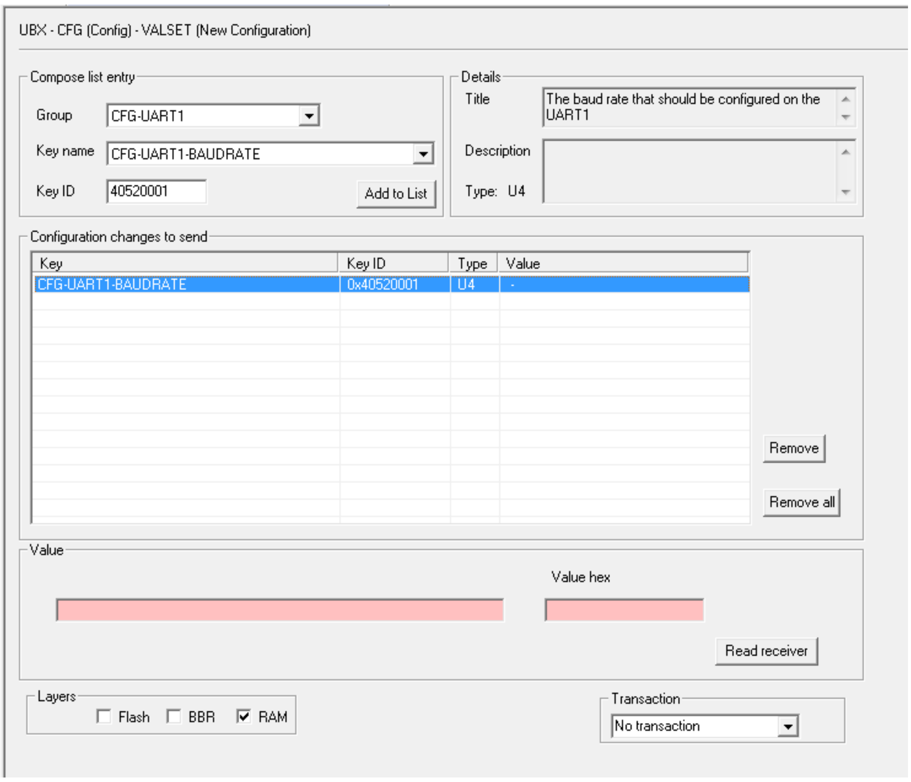


Figure 6: Example u-center UBX-CFG-VALSET message view when selecting a configuration item

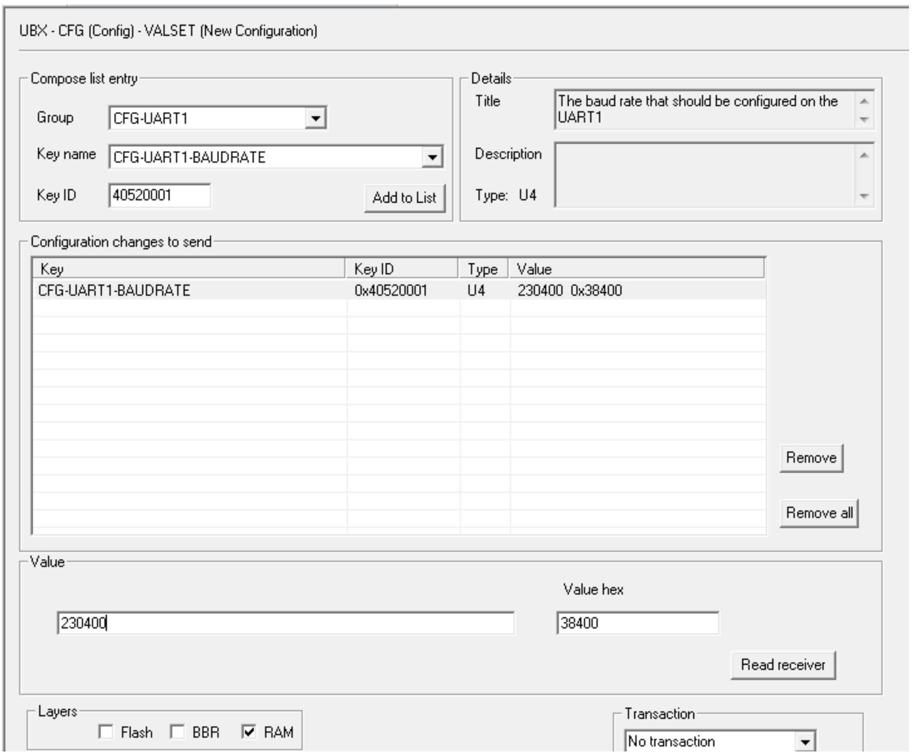


Figure 7: Base station: u-center UBX-CFG-VALSET message view for setting the CFG-UART1-BAUDRATE configuration item that controls the baudrate of UART1

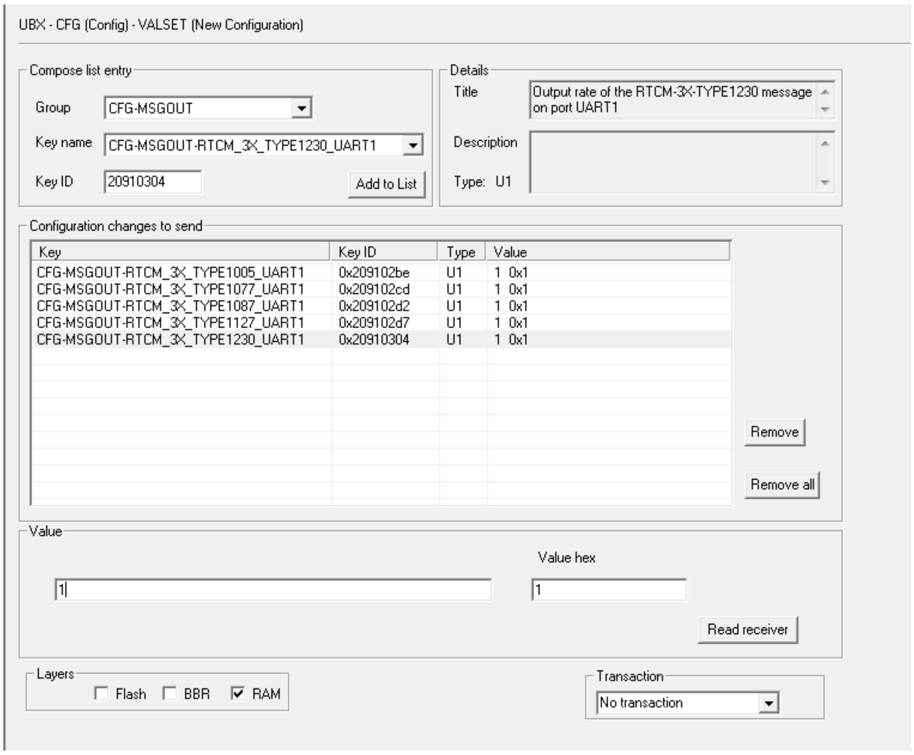


Figure 8: Base station: u-center UBX-CFG-VALSET message view for setting the CFG-MSGOUT-* configuration items for enabling the output of the required RTCM3 messages

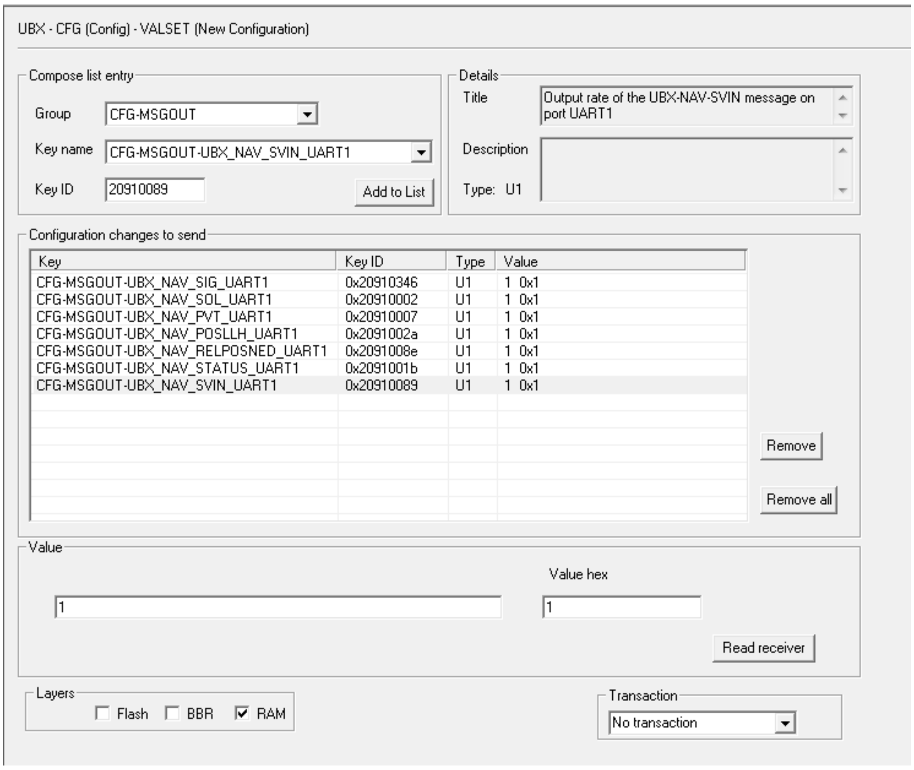


Figure 9: Base station: u-center UBX-CFG-VALSET message view for setting the CFG-MSGOUT-* configuration items for enabling the output of some recommended UBX messages

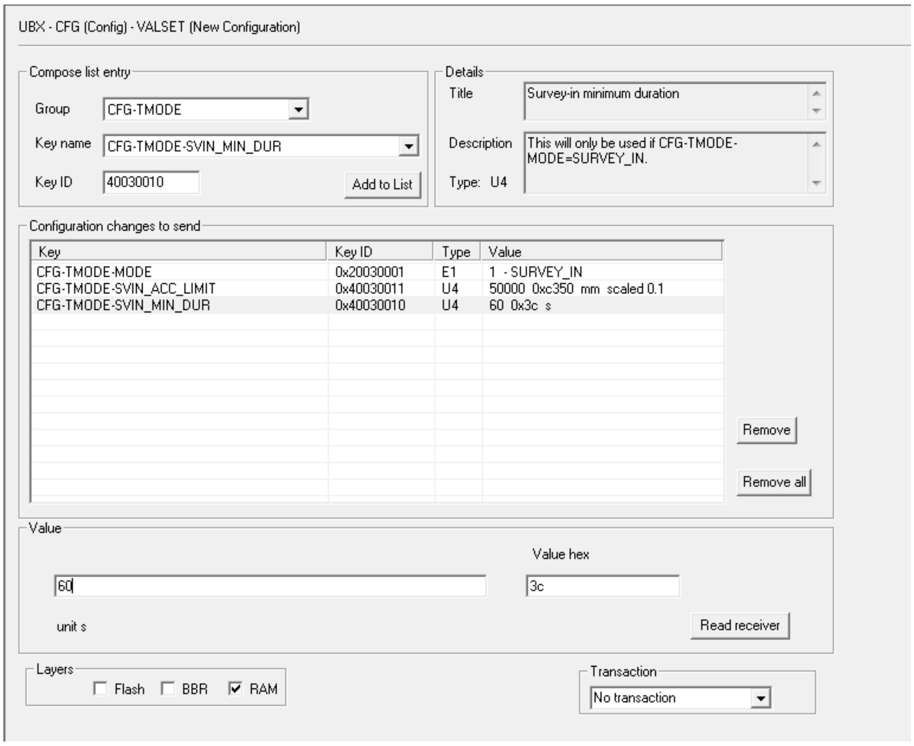


Figure 10: Base station: u-center UBX-CFG-VALSET message view for setting the CFG-TMODE-* configuration items required for performing a survey-in

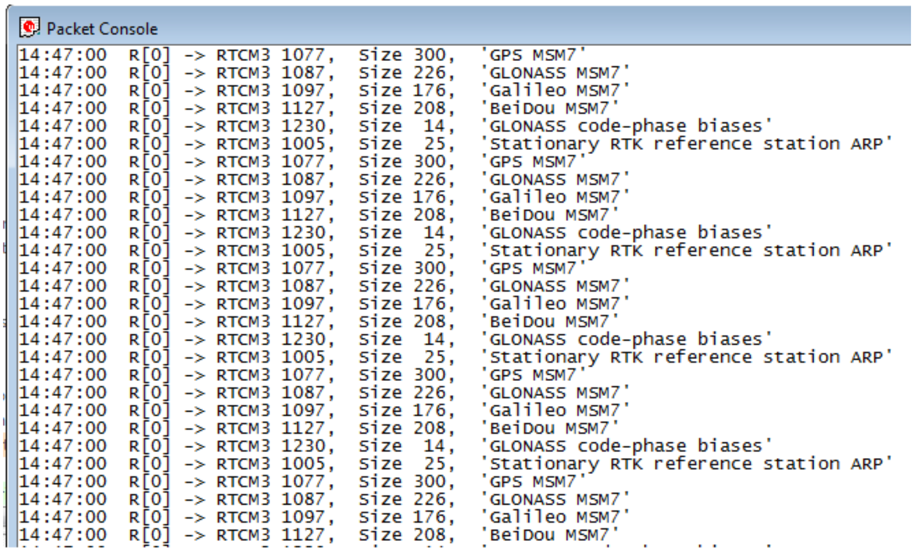


Figure 11: Base station: u-center packet console RTCM3 view

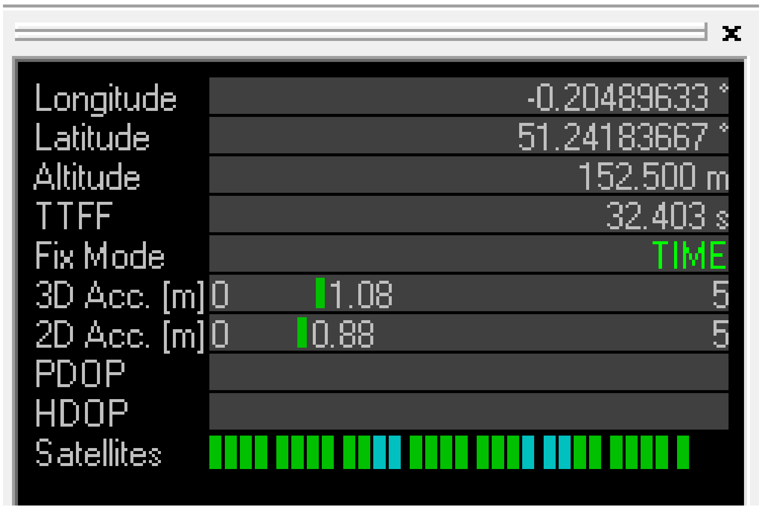


Figure 12: Base station: u-center data view in TIME mode

1.9.7 Rover: Configuration procedure overview

☞ This overview describes how to set the rover configuration by using the UBX-CFG-VALSET message view that is available in u-center 18.05 or newer. The UBX-CFG-VALSET message view needs to be set up for the configuration group and configuration keys that you wish to set. Once a configuration key is selected, you need to add it to the list by clicking the 'Add to List' button. Once it is in the 'Configuration changes to send' table you can edit or read the current receiver value. If you click on the Key item in the list, it will then be highlighted and allow you to set the value or read the current set value.

To configure the module for rover operation the following procedure needs to be carried out:

- Set the UART1 interface for the correct host baud rate.
    - Select Group: CFG-UART1, Key name: CFG-UART1-BAUDRATE. Please see Figure 13.
    - Add it to the list and highlight it. It will now give you the option of setting the value or reading the current value. Please see Figure 14.
    - Now add the value, e.g. 230400 baud, into the new Value window that appears below the list. Please see Figure 15.
    - Now set the configuration by clicking the Send button at the bottom of the message tree view. Remember to then set u-center baud rate to match the value you set in the receiver.
- We need to enable some UBX messages to view the status of the rover. Select Group CFG-MSGOUT, Key name: CFG-MSGOUT-UBX and select the UART1 required messages. Add each message to the list and then set the value of each to 1. Then click Send. Please see Figure 16.
- Please ensure all the required RTCM3 messages, most importantly RTCM 1005, are being received regularly by viewing the messages in the UBX-RXM-RTCM view in uCenter. Please see Figure 17
- Once the rover has started to receive valid RTCM3 messages, it will transition from 3D Fix to 3D/DGNSS to Float and to Fixed mode. This will only occur if it is receiving all required RTCM messages, including RTCM 1005, and the signal conditions are sufficient. Please see Figure 18
- Note that the receiver by default will attempt a RTK Fix solution, however it can be configured to use an RTK Float only solution by setting the CFG-NAVHPG-DGNSS configuration item.

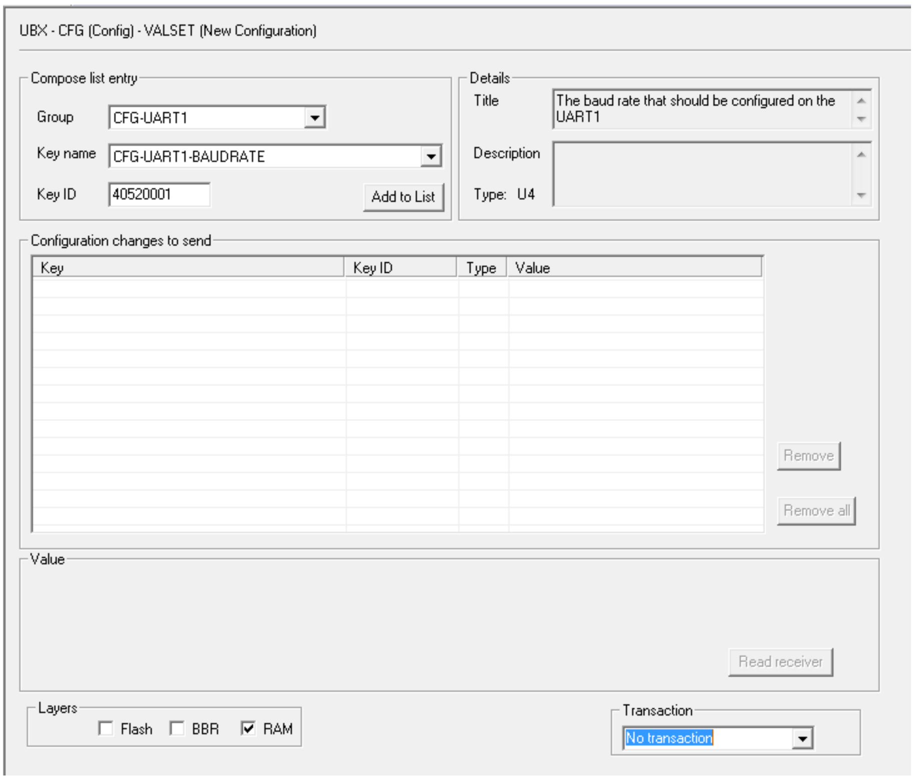


Figure 13: u-center UBX-CFG-VALSET message view

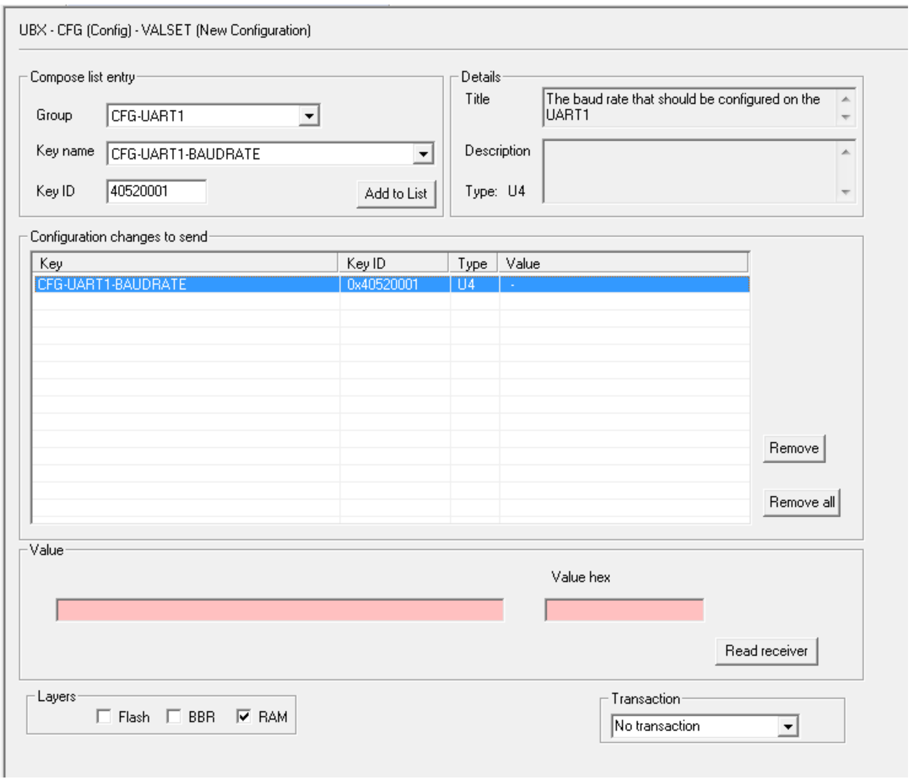


Figure 14: Example u-center UBX-CFG-VALSET message view when selecting a configuration item

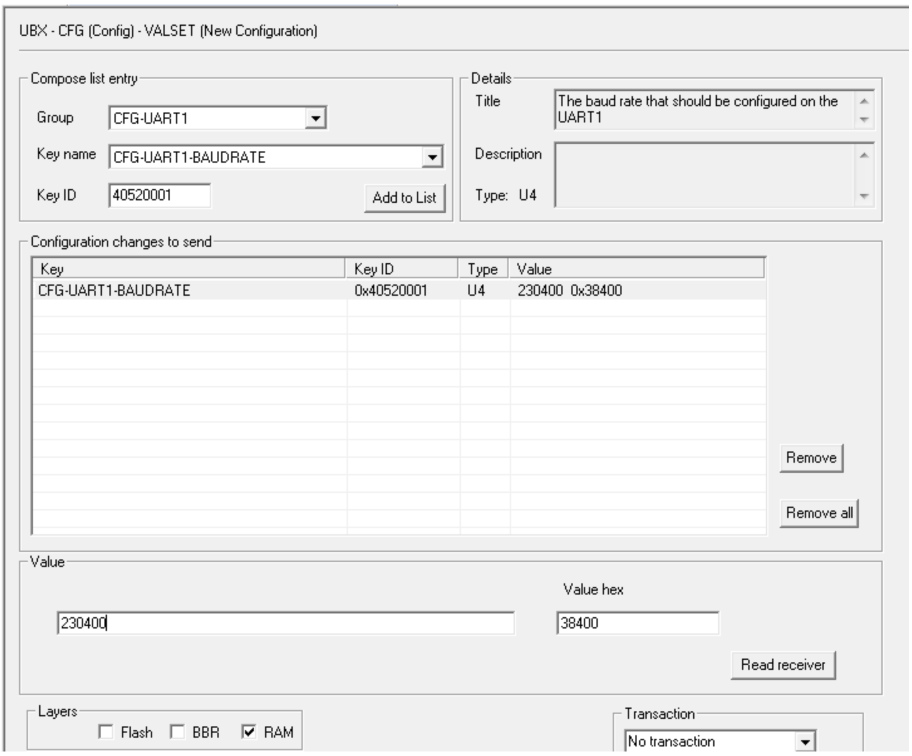


Figure 15: Rover: u-center UBX-CFG-VALSET message view for setting the CFG-UART1-BAUDRATE configuration item that controls the baudrate of UART1

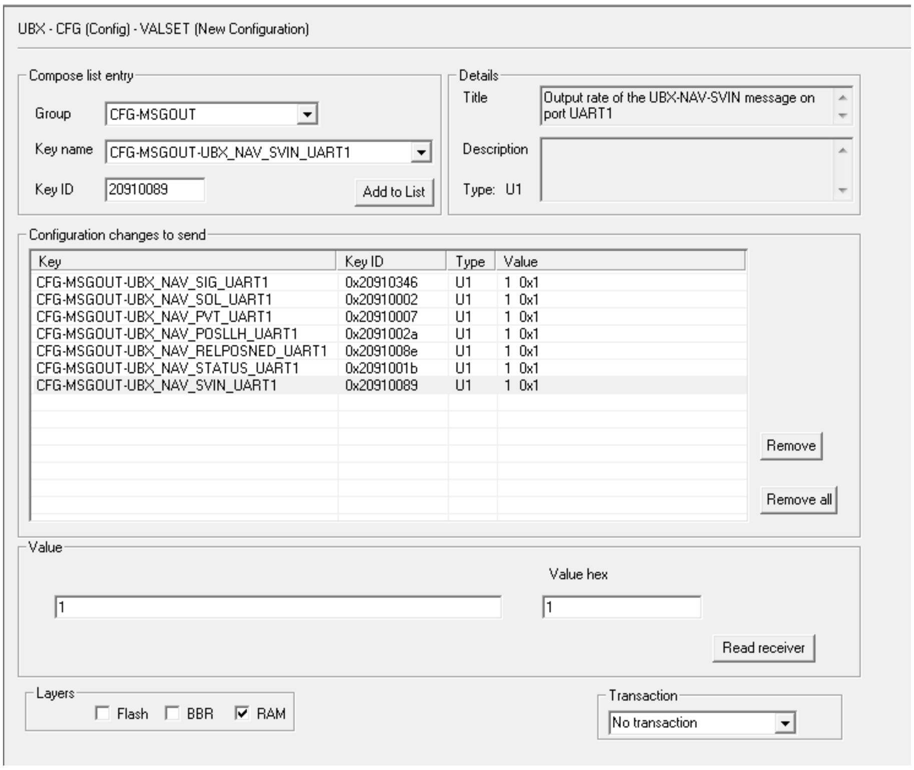
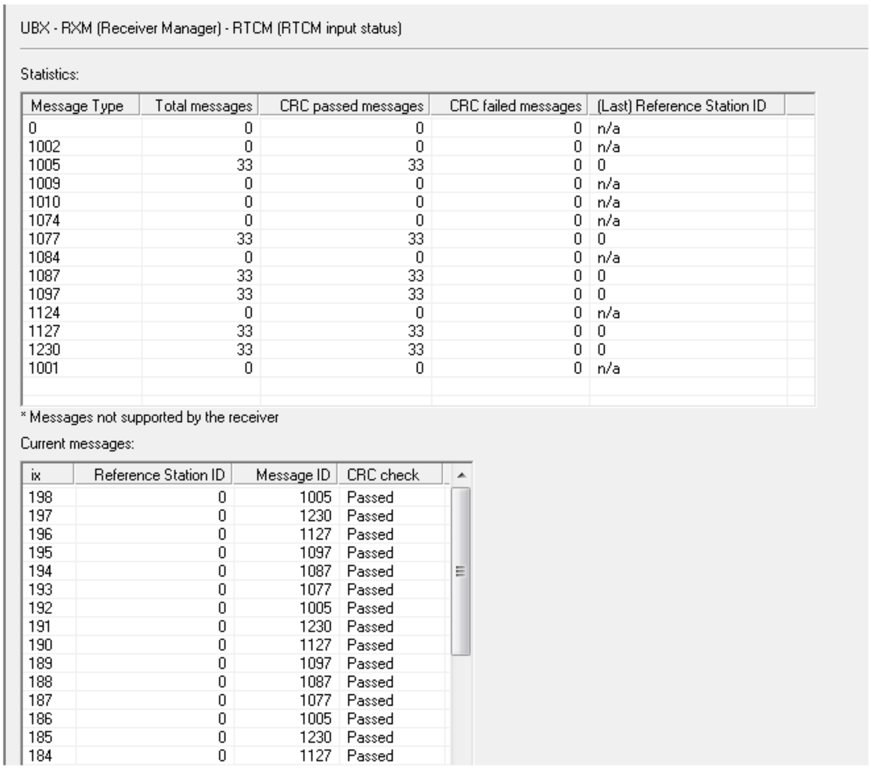


Figure 16: Rover: u-center UBX-CFG-VALSET message view for setting the CFG-MSGOUT-* configuration items for enabling the output of some recommended UBX messages



UBX - RXM (Receiver Manager) - RTCM (RTCM input status)

Statistics:

Message Type	Total messages	CRC passed messages	CRC failed messages	(Last) Reference Station ID
0	0	0	0	n/a
1002	0	0	0	n/a
1005	33	33	0	0
1009	0	0	0	n/a
1010	0	0	0	n/a
1074	0	0	0	n/a
1077	33	33	0	0
1084	0	0	0	n/a
1087	33	33	0	0
1097	33	33	0	0
1124	0	0	0	n/a
1127	33	33	0	0
1230	33	33	0	0
1001	0	0	0	n/a

* Messages not supported by the receiver

Current messages:

ix	Reference Station ID	Message ID	CRC check
198	0	1005	Passed
197	0	1230	Passed
196	0	1127	Passed
195	0	1097	Passed
194	0	1087	Passed
193	0	1077	Passed
192	0	1005	Passed
191	0	1230	Passed
190	0	1127	Passed
189	0	1097	Passed
188	0	1087	Passed
187	0	1077	Passed
186	0	1005	Passed
185	0	1230	Passed
184	0	1127	Passed

Figure 17: Rover: u-center UBX-RXM-RTCM view

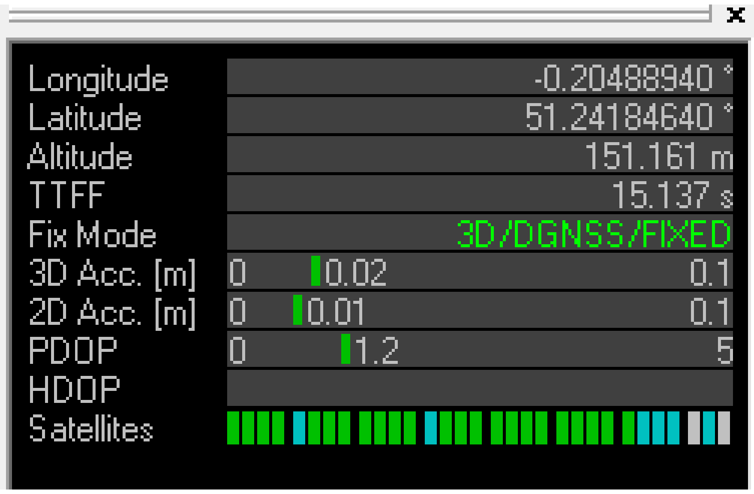


Figure 18: Rover: u-center data view with RTK Fixed

1.10 Legacy command Configuration

☞ The early Beta firmware for the ZED-F9P still accepts the legacy UBX-CFG messages, however these messages are now deprecated on ZED-F9P and have been replaced by new configuration messages that should be used instead of the older UBX-CFG messages. The new messages that should be used are the UBX-CFG-VALSET, UBX-CFG-VALGET, and UBX-CFG-VALDEL messages and are supported on the early Beta firmware. Please see the u-blox ZED-F9P Interface Description [2].

1.10.1 Base configuration

To configure the module for base operation the following procedure needs to be carried out:

- Set the UART1 interface for the correct Host baud rate and ensure RTCM3 output protocol has been enabled using the UBX-CFG-PRT message. Please see Figure 19
- Enable the minimum list of required RTCM3 output message on the UART1 interface using the UBX-CFG-MSG message. Please see Figure 20
- Set the unit into base mode by enabling Survey In or Fixed Mode by using the UBX-CFG-TMODE3 message. Please see Figure 21
- The unit will then output all the messages once it has completed Survey In or once Fixed Mode has been enabled with the required base antenna co-ordinates. If using the Survey In mode, sensible settings must be selected based on the environment and achievable accuracy in the base location. The base will not typically achieve less than a real 1 m accuracy in good conditions, in obstructed multi-path conditions this figure could be higher and the Survey In time to achieve even the lower accuracy can take longer than expected. The base antenna might need to be moved to a better location or the required accuracy and/or Survey In time might need to be extended. Please verify with the Survey In status using UBX-NAV-SVIN message. Please see Figure 22 to verify all RTCM3 messages are being output. RTCM3 MSG 1005 will **only** be output once Survey In is completed or the Fixed co-ordinates are entered for the base antenna.

Attention If the base is moved, then Survey In must be repeated or the base must be set again into Fixed Mode using the new coordinates.

In the example figure below the base is set with a UART baud rate 230400 baud and only RTCM3 protocol output is enabled on UART1.

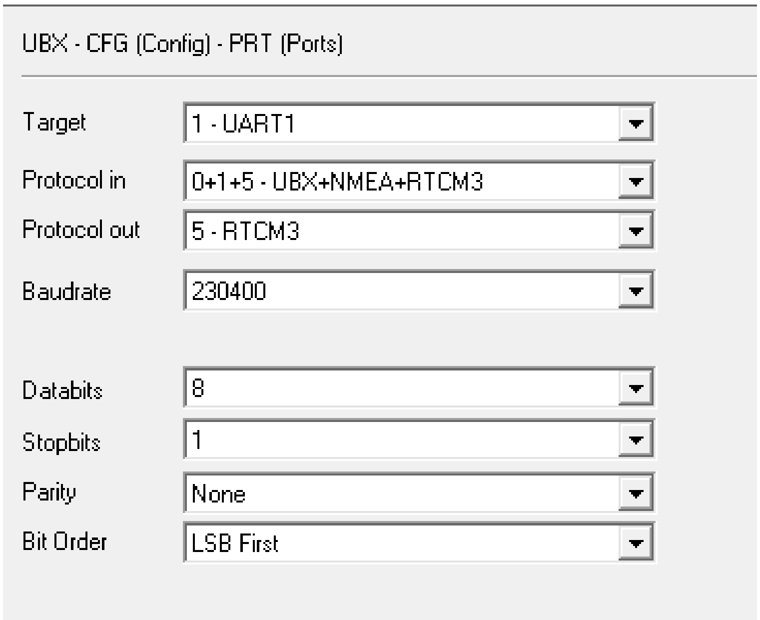


Figure 19: Base u-center UART1 UBX-CFG-PRT view

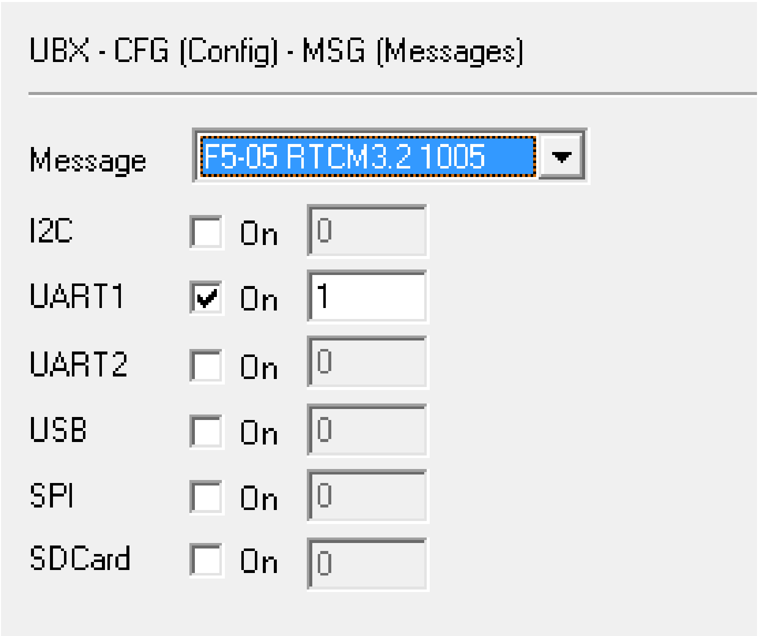


Figure 20: Base u-center UART1 UBX-CFG-MSG view

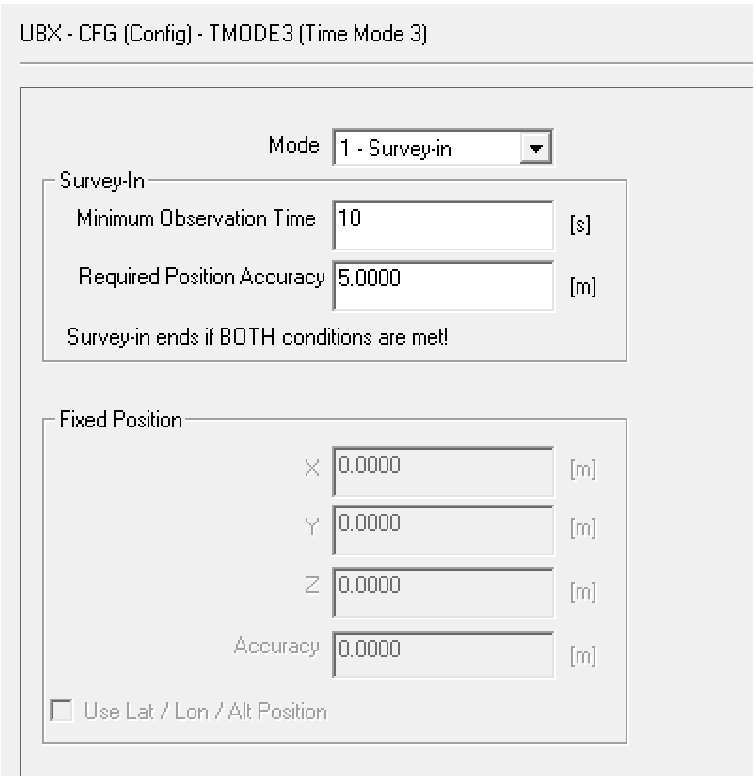


Figure 21: Base u-center UBX-CFG-TMODE3 view

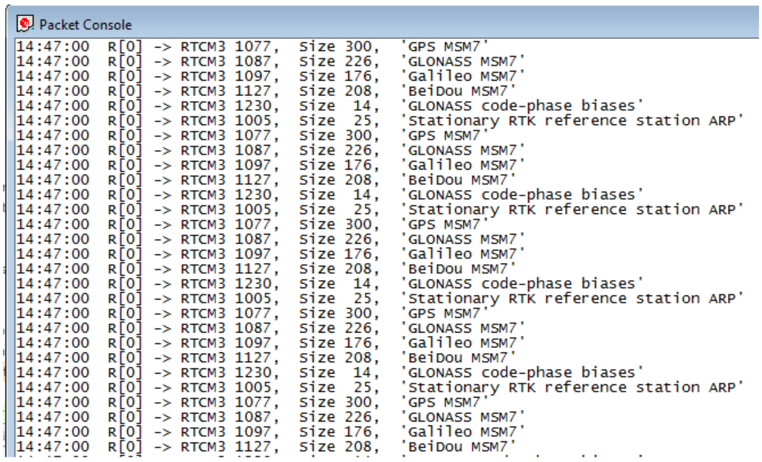


Figure 22: Base u-center packet console RTCM3 view

1.10.2 Rover configuration

For rover operation the following procedure needs to be carried out:

- Set the UART1 interface for the correct Host baud rate and ensure RTCM3 input protocol has been enabled using UBX-CFG-PRT message. Please see Figure 23
- Ensure the minimum list of RTCM3 input messages are being received continuously by using the UBX-RXM-RTCM message. Please see Figure 24
- The rover will indicate DGNSS then FLOAT and finally FIXED mode when the required conditions for RTK have been met. Please see Figure 25

☞ If the correction stream comes from a VRS caster, the VRS caster needs to know the location of the rover receiver. To do this the rover has to output the NMEA GGA message and this has to be sent to the VRS Caster. Typically only the NMEA GGA message is needed.

The example below if for RTCM3 and not VRS.

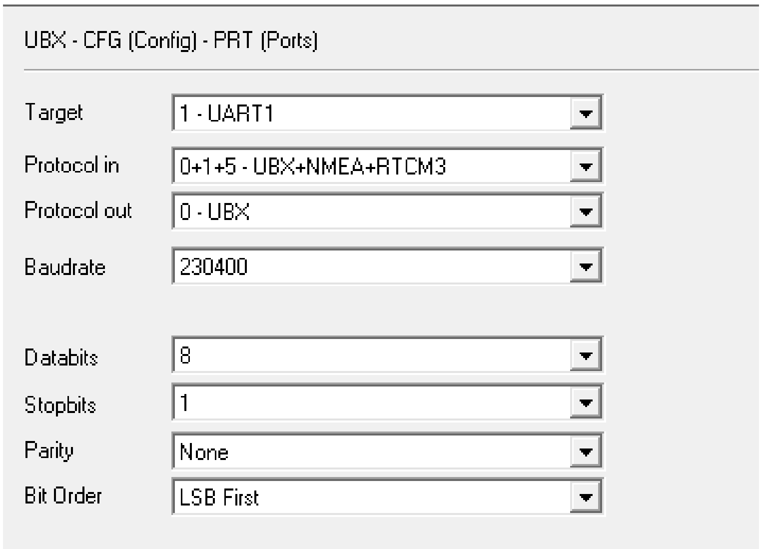
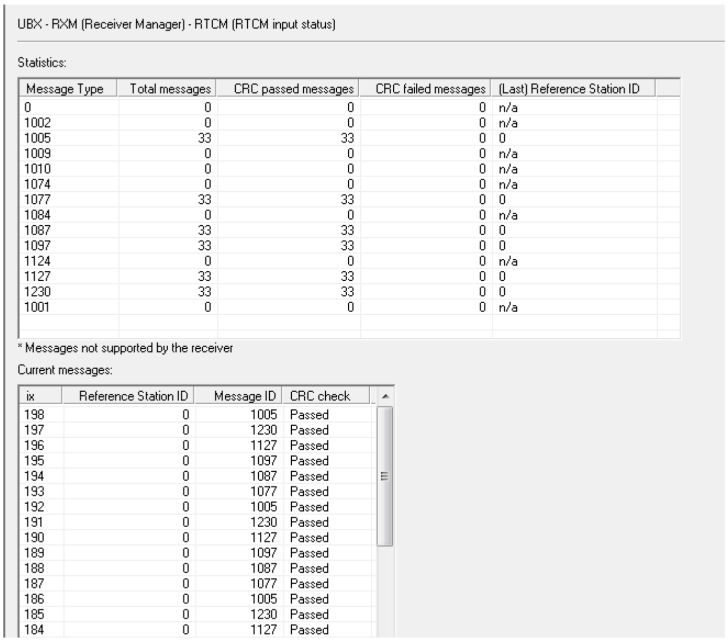


Figure 23: Rover u-center UART1 UBX-CFG-PRT view



UBX - RXM (Receiver Manager) - RTCM (RTCM input status)

Statistics:

Message Type	Total messages	CRC passed messages	CRC failed messages	(Last) Reference Station ID
0	0	0	0	n/a
1002	0	0	0	n/a
1005	33	33	0	0
1009	0	0	0	n/a
1010	0	0	0	n/a
1074	0	0	0	n/a
1077	33	33	0	0
1084	0	0	0	n/a
1087	33	33	0	0
1097	33	33	0	0
1124	0	0	0	n/a
1127	33	33	0	0
1230	33	33	0	0
1001	0	0	0	n/a

* Messages not supported by the receiver

Current messages:

ix	Reference Station ID	Message ID	CRC check
198	0	1005	Passed
197	0	1230	Passed
196	0	1127	Passed
195	0	1097	Passed
194	0	1087	Passed
193	0	1077	Passed
192	0	1005	Passed
191	0	1230	Passed
190	0	1127	Passed
189	0	1097	Passed
188	0	1087	Passed
187	0	1077	Passed
186	0	1005	Passed
185	0	1230	Passed
184	0	1127	Passed

Figure 24: Rover u-center UBX-RXM-RTCM view

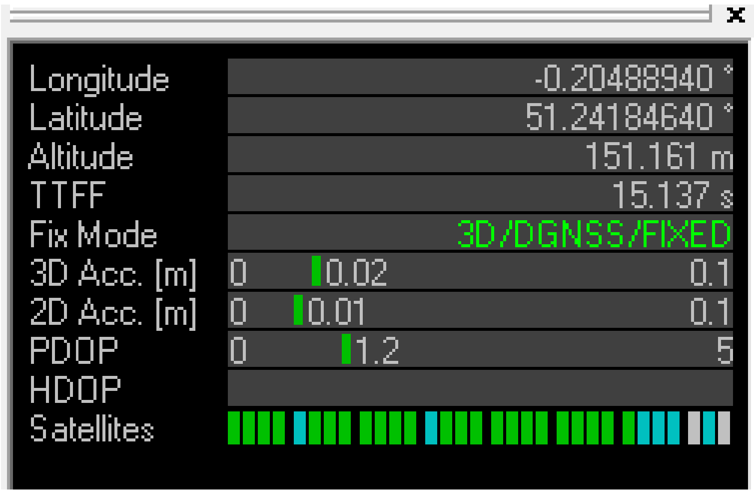


Figure 25: Rover u-center data view

1.10.3 Rover VRS configuration

For VRS operation the rover needs NMEA protocol output enabled on UART1 and NMEA GGA message enabled on UART1. Please see Figure 26 and Figure 27

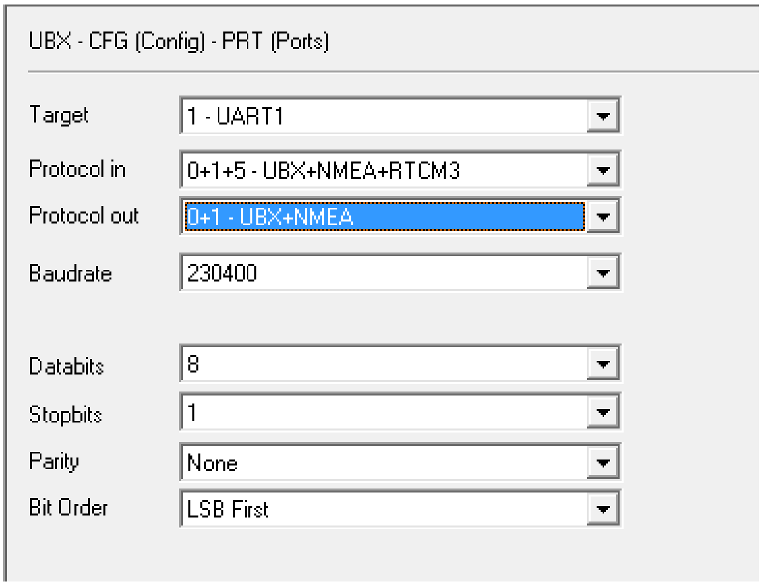


Figure 26: Rover u-center UBX-CFG-PRT view

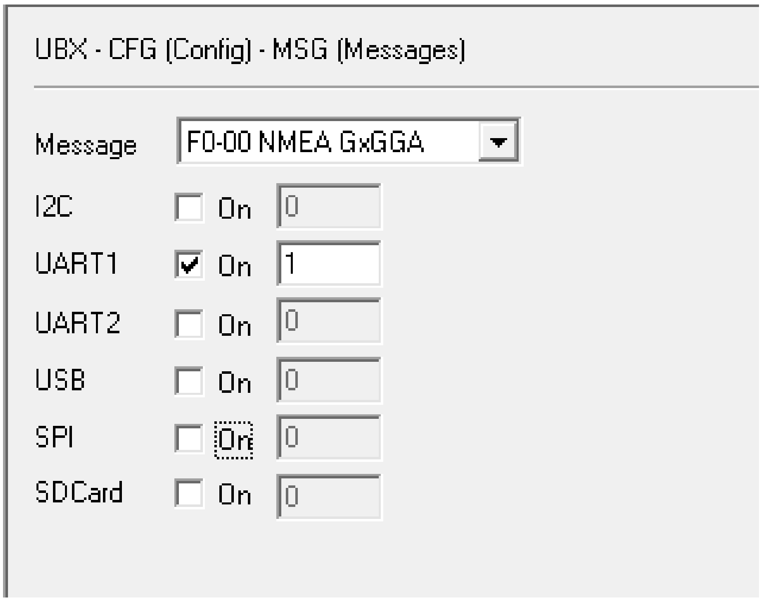


Figure 27: Rover u-center UBX-CFG-MSG view

1.11 Default messages

Interface	Settings
UART1 Output	38400 Baud, 8 bits, no parity bit, 1 stop bit. Configured to transmit NMEA, UBX, RTCM3 protocols. But only the following NMEA (and no UBX) messages have been activated at start-up: **GGA, GLL, GSA, GSV, RMC, VTG, TXT**.
UART1 Input	38400 Baud, 8 bits, no parity bit, 1 stop bit. Automatically accepts following protocols without need of explicit configuration: UBX, NMEA, RTCM3.
UART2 Output	38400 Baud, 8 bits, no parity bit, 1 stop bit. No Host interface. Configured to only transmit RTCM3 protocols.
UART2 Input	38400 Baud, 8 bits, no parity bit, 1 stop bit. No Host interface. Automatically accepts only the following protocols without need of explicit configuration: RTCM3.

Interface	Settings
DDC	Fully compatible with the I^2C industry standard, available for communication with an external host CPU or u-blox cellular modules, operated in slave mode only. Default messages activated as in UART1. Input/output protocols available as in UART1. Maximum bit rate 400 kb/s.
SPI	Allow communication to a host CPU, operated in slave mode only. Default messages activated as in UART1. Input/output protocols available as in UART1. SPI is not available unless the D_SEL interface is set up accordingly (see D_SEL interface).
TIMEPULSE (1 Hz Nav)	1 pulse per second, synchronized at rising edge, pulse length 100 ms

Table 8: Default messages

☞ With firmware version 1.00B03 it is not possible to use the UART2 as an RTCM interface.

☞ Refer to the u-blox ZED-F9P Interface Description [2] for information about further settings.

☞ The ZED-F9P outputs NMEA 4.1 messages that includes satellite data for all GNSS bands being received. This results in many more NMEA messages being output for each navigation period. Please ensure the UART1 baud rate being used is sufficient for the set Navigation rate and the amount of GNSS signals being received.

2 Hardware description

2.1 Block diagram

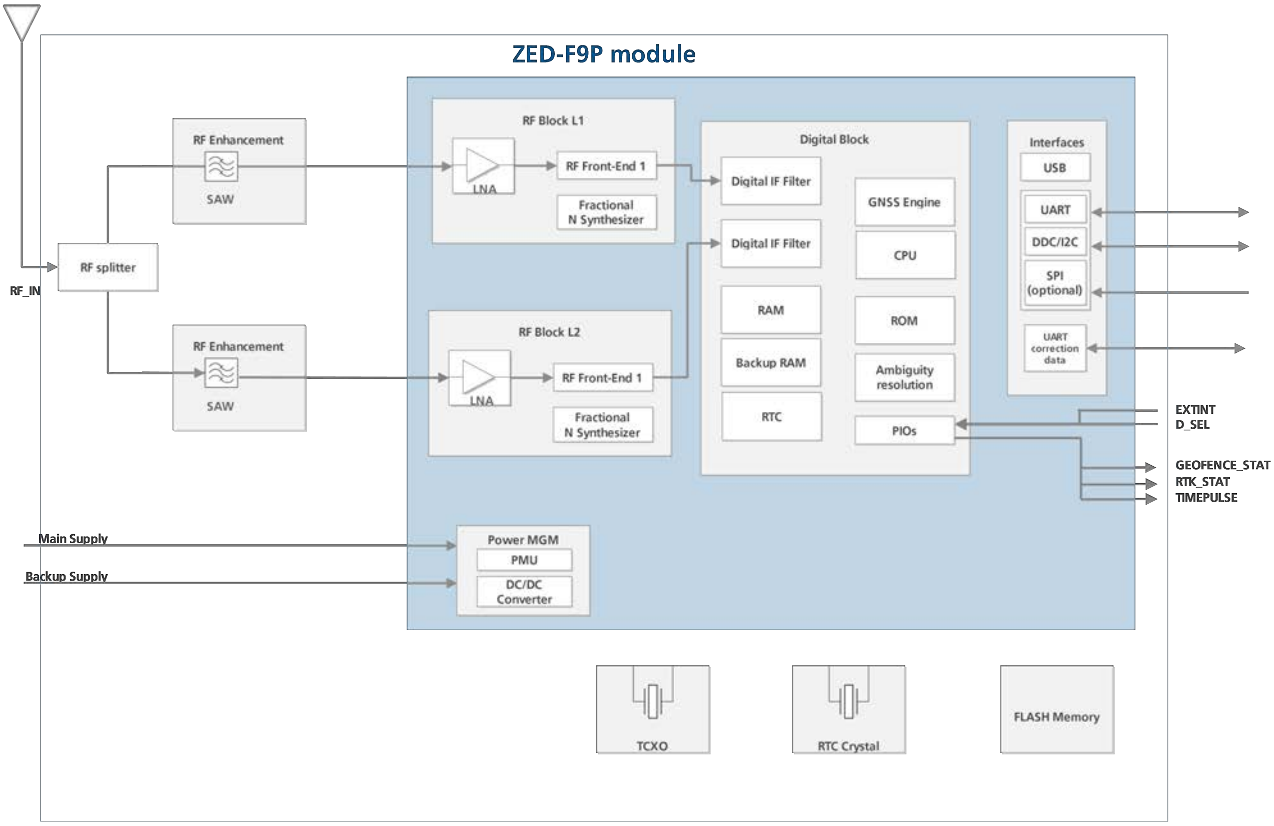


Figure 28: ZED-F9P block diagram

2.2 Connecting Power

The u-blox ZED-F9P modules have two power supply pins: VCC, V_BCKP.

2.2.1 VCC: Main supply voltage

The **VCC** pin provides the main supply voltage. During operation, the current drawn by the module can vary by some orders of magnitude. For this reason, it is important that the supply circuitry be able to support the peak power for a short time (see the u-blox u-blox ZED-F9P Data sheet [1] for specification).

☞ When switching from backup mode to normal operation or at start-up, u-blox ZED-F9P modules must charge the internal capacitors in the core domain. In certain situations, this can result in a significant current draw. At least 300 mA with no drop in VCC voltage must be supported just for the module. For low power applications using backup mode, it is important that the power supply or low ESR capacitors at the module input can deliver this current/ charge.

☞ Do not use any resistors or coils in the power line.

☞ Do not add any series resistance greater than 0.2 Ω to the VCC supply as it will generate input voltage noise due to the dynamic current conditions.

☞ For the ZED-F9P module the equipment must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1.

2.2.2 V_BCKP: Backup supply voltage

If the module supply has a power failure, the **V_BCKP** pin supplies the real-time clock (RTC) and battery backed RAM (BBR). Use of valid time and the GNSS orbit data at start up will improve the GNSS performance, as with hot starts and warm starts. If no backup battery is connected, the module performs a cold start at power up.

The module integrates a DC/DC converter, allowing reduced power consumption especially when using a main supply voltage above 2.5 V.

☞ Avoid high resistance on the **V_BCKP** line: During the switch from main supply to backup supply, a short current adjustment peak can cause high voltage drop on the pin with possible malfunctions.

☞ If no backup supply voltage is available, connect the **V_BCKP** pin to **VCC**.

☞ As long as power is supplied to the ZED-F9P module through the **VCC** pin, the backup battery is disconnected from the RTC and the BBR to avoid unnecessary battery drain. In this case, **VCC** supplies power to the RTC and BBR.

☞ Please connect to ground or allow all I/O including UART and other interfaces to Float/High impedance in HW backup mode (Battery Back-up connected with VCC removed). If this is not done HW backup current is not stable and has a very high variation.

Real-Time Clock (RTC)

The Real-Time Clock (RTC) is driven by a 32 kHz oscillator using an RTC crystal. If the main supply voltage fails, and a battery is connected to **V_BCKP**, parts of the receiver switch off, but the RTC still runs providing a timing reference for the receiver. This operating mode is called Hardware Backup Mode, which enables all relevant data to be saved in the backup RAM to allow a hot or warm start later

2.2.3 ZED-F9P Power supply

The ZED-F9P high precision receiver requires a low noise, low dropout voltage, very low source impedance power supply of 3.3V typically. No inductors or Ferrite beads should be used from LDO to the module VCC pin, less than 0.2 Ohm source impedance is required feeding the module. The peak currents need to be taken into account for the source supplying the LDO for the module. We would recommend that the source supplying the module LDO can supply 300 mA with no drop in supply voltage.

A power supply fed by 5V is shown in the figure below. This supply is intended just for the module.

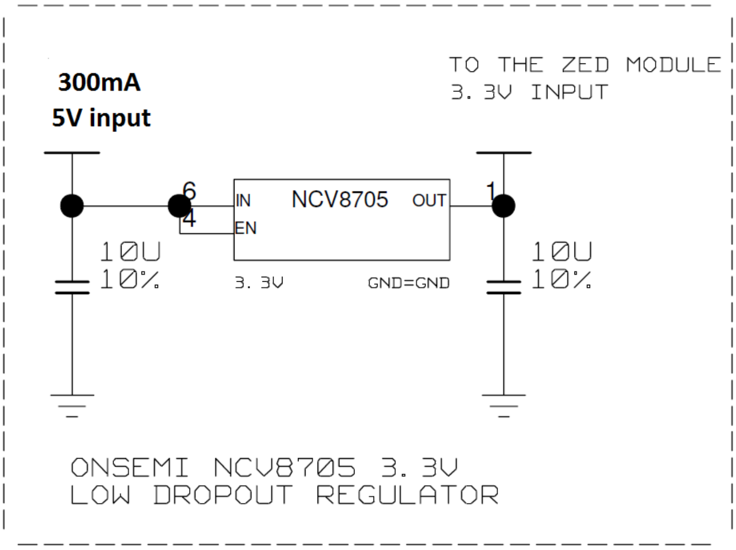


Figure 29: ZED-F9P power supply

2.3 Interfaces

A number of interfaces are available in the ZED-F9P high precision receiver (UART and SPI, DDC), but not all supported by firmware for data communication. The firmware uses these interfaces according to their respective protocol specifications. For specification of the protocols please see the u-blox ZED-F9P Interface Description [2].

2.3.1 UART interfaces

UART1

The ZED-F9P high precision receiver makes use of a UART interface, which can be used for communication with a host. It supports configurable baud rates.

UART2

There is a second UART interface UART2 that has no Host interface capability (no UBX or NMEA messages). This interface is primarily intended for interfacing to a satellite correction receiver.

☞ With firmware version 1.00B03 it is not possible to use the UART2 as an RTCM interface.

☞ With firmware version 1.00B03 the default baud rate is 38400 baud and it is not recommended to run at a baud rate lower than this with the default NMEA messages.

2.3.2 SPI interface

The ZED-F9P high precision receiver has a SPI slave interface that can be selected by setting D_SEL = 0. The SPI slave interface is shared with UART1. The SPI pins available are: SPI_MISO (TXD), SPI_MOSI (RXD), SPI_CS_N, SPI_CLK. The SPI interface is designed to allow communication to a host CPU. The interface can be operated in slave mode only. The maximum transfer rate using SPI is 125kB/s and the maximum SPI clock frequency is 5.5 MHz.

2.3.3 D_SEL interface

The ZED-F9P high precision receiver has a D_SEL pin that allows the selection between UART1 and SPI interface at power On. By default with D_SEL not connected or pulled up, the ZED-F9P is using UART1 interface and DDC and there is no SPI interface.

2.3.4 RESET_N interface

The ZED-F9P high precision receiver provides a RESET_N pin to reset the system. The RESET_N pin is an input-only pin with an internal pull-up resistor. It is recommended that if a Reset is required that this input be pulled to a low level for at least 100 ms. This is to ensure that an input Reset is detected on the RESET_N pin. Please leave the RESET_N pin open for normal operation. The RESET_N input complies with the V_IO level and can be actively driven high.

2.3.5 SAFEBOOT_N interface

The ZED-F9P high precision receiver provides a SAFEBOOT_N pin that is used to command the receiver into SAFEBOOT. If this pin is low at start up, the receiver starts in Safe Boot Mode and does not begin GNSS operation. In Safe Boot Mode the receiver runs from an internal LC oscillator. Thus it can be used to recover from situations where the SQI Flash has become corrupted. Owing to the inaccurate frequency of the internal LC oscillator, the receiver is unable to communicate via USB in Safe Boot Mode. For communication by UART in Safe Boot Mode, a training sequence (0x 55 55 at 9600 baud) can be sent by the host to the receiver in order to enable communication. After sending the training sequence the host has to wait for at least 2 ms before sending messages to the receiver. Safe Boot Mode is used in production to program the SQI Flash and to set the Low Level Configuration in the eFuse. It is recommended to have the possibility to pull the SAFEBOOT_N pin low when the receiver starts up. This can be provided using an externally connected test point or via a host CPUs digital I/O port.

2.3.6 TIMEPULSE interface

The ZED-F9P high precision receiver provides a time pulse on the TIMEPULSE pin.

2.3.7 TX_READY interface

The TX_READY function is used to indicate when the receiver has data to transmit. A listener can wait on the TX_READY signal instead of polling the DDC or SPI interfaces. The UBX-CFG-PRT message lets you configure the polarity and the number of bytes in the buffer before the TX READY signal goes active. The TX_READY function is disabled by default.

2.3.8 USB debug interface

The debug interface is compatible with the USB version 2.0 FS (Full Speed, 12 Mb/s) interface. This interface does not support firmware update.

☞ Please contact u-blox support for information on drivers as these are not released.

☞ USB suspend is not supported.

☞ USB bus powered is not supported.

Pin 38, V_USB needs to be connected to the module VCC. Pin 39 is USB_DM. Pin 48 is USB_DP. 27 Ω resistors are required in line with the USB_DM and USB_DP lines.

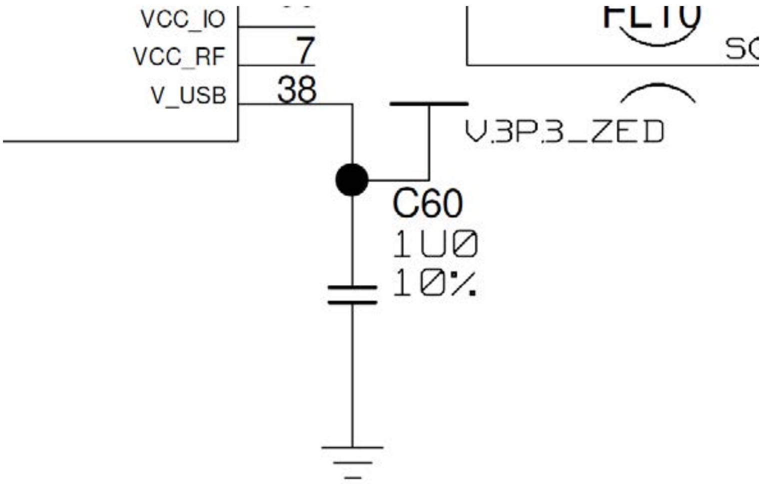


Figure 30: V_USB connected to VCC

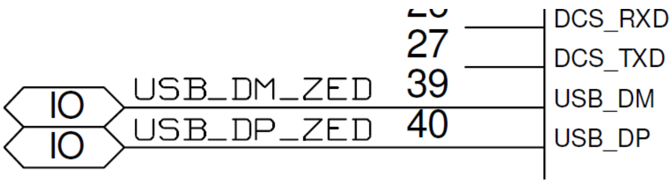


Figure 31: ZED-F9P USB_DM and USB_DP pins

For connecting the debug USB interface to external equipment additional components are required such as filtering and a connector

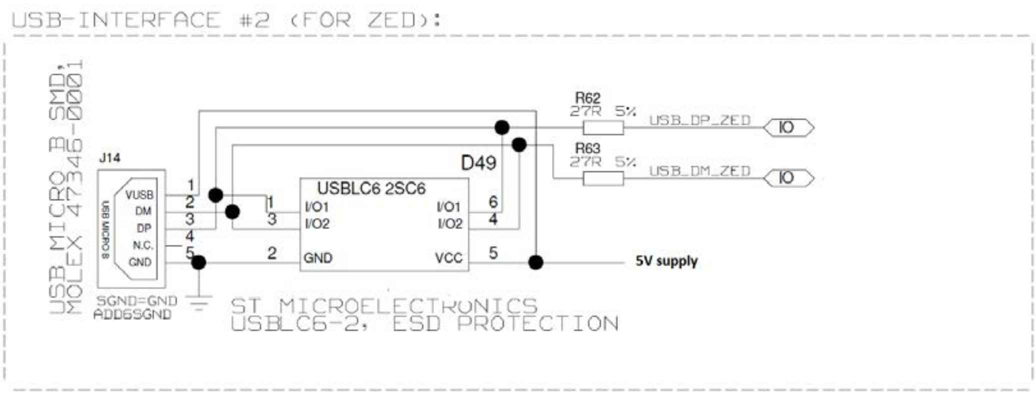


Figure 32: External debug USB interface

2.3.9 Display Data Channel (DDC)

An I^2C compliant DDC interface is available for communication with an external host CPU or u-blox cellular modules. The interface can be operated in slave mode only. The DDC protocol and electrical interface are fully compatible with Fast-Mode of the I^2C industry standard. Since the maximum SCL clock frequency is 400 kHz, the maximum transfer rate is 400 kb/s.

2.3.10 Antenna supervisor

An active antenna supervisor provides the means to check the antenna for open and short circuits and to shut off the antenna supply if a short circuit is detected. The Antenna Supervisor is configured using serial port UBX binary protocol message. Once enabled, the active antenna supervisor produces status messages, reporting in NMEA and/or UBX binary protocol.

The current active antenna status can be determined by polling the UBX-MON-HW monitor command. If an antenna is connected, the initial state after power-up is “Active Antenna OK.”

The module firmware supports an active antenna supervisor circuit, which is connected to the ANT_DET_N, ANT_OFF, ANT_SHORT_N pins. For an example the open circuit detection circuit using ANT_DET_N, "high" = Antenna detected (antenna consumes current); "low" = Antenna not detected (no current drawn).

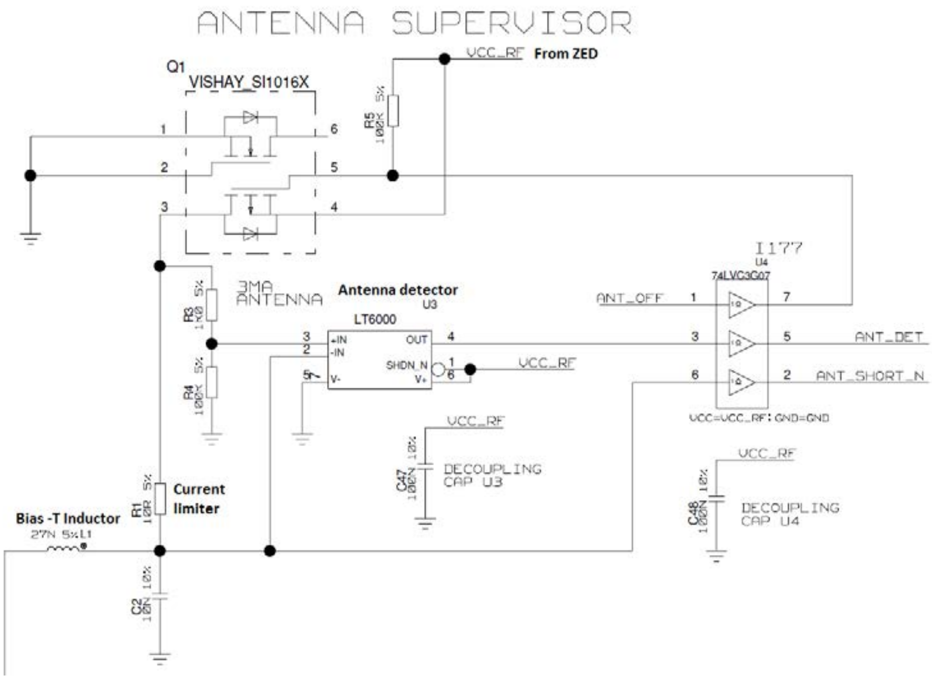


Figure 33: ZED-F9P Antenna Supervisor

2.3.11 EXTINT

EXTINT is an external interrupt pin with fixed input voltage thresholds with respect to VCC. They can be used for aiding. Leave open if unused.

3 EOS/ESD/EMI precautions

When integrating GNSS receivers into wireless systems, careful consideration must be given to electromagnetic and voltage susceptibility issues. Wireless systems include components which can produce Electrostatic Discharge (ESD), Electrical Overstress (EOS) and Electro-Magnetic Interference (EMI). CMOS devices are more sensitive to such influences because their failure mechanism is defined by the applied voltage, whereas bipolar semiconductors are more susceptible to thermal overstress. The following design guidelines are provided to help in designing robust yet cost effective solutions.

⚠ **Attention** To avoid overstress damage during production or in the field it is essential to observe strict EOS/ESD/EMI handling and protection measures.

⚠ **Attention** To prevent overstress damage at the RF_IN of your receiver, never exceed the maximum input power as specified in the u-blox ZED-F9P Data sheet [1].

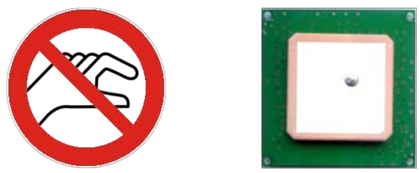
3.1 ESD handling precautions

⚠ **Attention** ZED-F9P high precision receivers contain highly sensitive electronic circuitry and are Electrostatic Sensitive Devices (ESD). Observe precautions for handling! Failure to observe these precautions can result in severe damage to the GNSS receiver!

- Unless there is a galvanic coupling between the local GND (i.e. the work table) and the PCB GND, then the first point of contact when handling the PCB must always be between the local GND and PCB GND.
- Before mounting an antenna patch, connect ground of the device.

- When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10 pF, coax cable ~50-80 pF/m, soldering iron, ...)

- To prevent electrostatic discharge through the RF input, do not touch any exposed antenna area. If there is any risk that such exposed antenna area is touched in non ESD protected work area, implement proper ESD protection measures in the design.



- When soldering RF connectors and patch antennas to the receiver's RF pin, make sure to use an ESD safe soldering iron (tip).

3.2 ESD protection measures

⚠ **Attention** GNSS receivers are sensitive to Electrostatic Discharge (ESD). Special precautions are required when handling. Most defects caused by ESD can be prevented by following strict ESD protection rules for production and handling. When implementing passive antenna patches or external antenna connection points, then additional ESD measures as shown in the figure below can also avoid failures in the field.

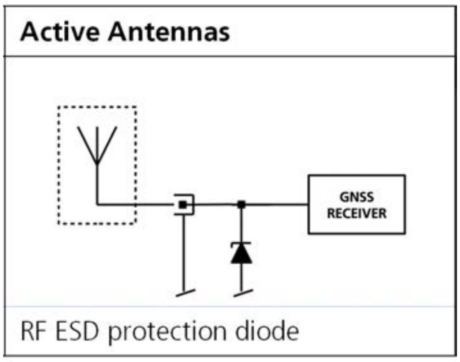


Figure 34: RF ESD precautions

3.3 EOS precautions

Electrical Overstress (EOS) usually describes situations when the maximum input power exceeds the maximum specified ratings. EOS failure can happen if RF emitters are close to a GNSS receiver or its antenna. EOS causes damage to the chip structures. If the RF_IN is damaged by EOS, it's hard to determine whether the chip structures have been damaged by ESD or EOS.

EOS protection measures as shown in the figure below are recommended for any designs combining wireless communication transceivers (e.g. GSM, GPRS) and GNSS in the same design or in close proximity.

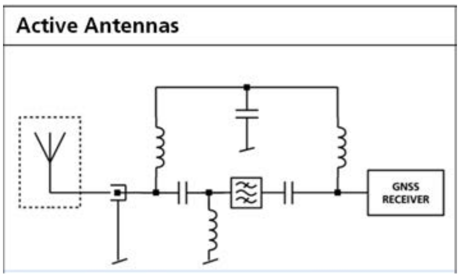


Figure 35: Active antenna EOS protection

3.4 Safety precautions

The ZED-F9P must be supplied by an external limited power source in compliance with the clause 2.5 of the standard IEC 60950-1. In addition to external limited power source, only Separated or Safety Extra-Low Voltage (SELV) circuits are to be connected to the module including interfaces and antennas.

☞ For more information about SELV circuits see section 2.2 in Safety standard IEC 60950-1

4 Electromagnetic interference on I/O lines

Any I/O signal line with a length greater than approximately 3 mm can act as an antenna and may pick up arbitrary RF signals transferring them as noise into the GNSS receiver. This specifically applies to unshielded lines, in which the corresponding GND layer is remote or missing entirely, and lines close to the edges of the printed circuit board. If, for example, a cellular signal radiates into an unshielded high-impedance line, it is possible to generate noise in the order of volts and not only distort receiver operation but also damage it permanently. Another type of interference can be caused by noise generated at the PIO pins that emits from unshielded I/O lines. Receiver performance may be degraded when this noise is coupled into the GNSS antenna. To avoid interference by improperly shielded lines, it is recommended to use resistors or ferrite beads on the I/O lines in series. These components should be chosen with care because they will affect also the signal rise times. Alternatively, feed-thru capacitors with good GND connection close to the GNSS receiver can be used. EMI protection measures are particularly useful when RF emitting devices are placed next to the GNSS receiver and/or to minimize the risk of EMI degradation due to self-jamming. An adequate layout with a robust grounding concept is essential in order to protect against EMI.

It is recommended that EMI filters or resistors are placed on the I/O lines as shown below:

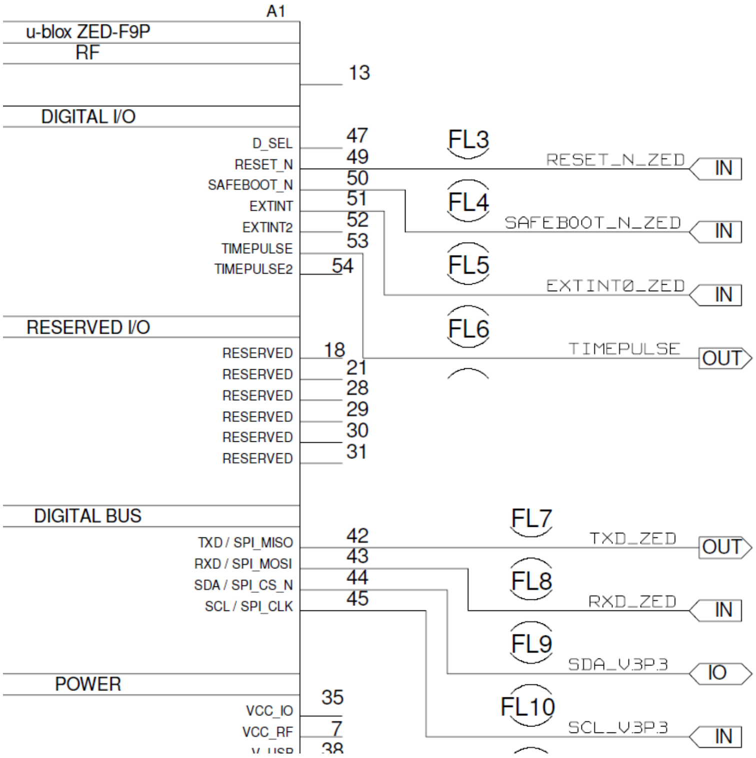


Figure 36: ZED-F9P EMI protection

☞ Intended Use: In order to mitigate any performance degradation of a radio equipment under EMC disturbance, system integration shall adopt appropriate EMC design practice and not contain cables over three meters on signal and supply ports.

4.1 General notes on interference issues

Received GNSS signal power at the antenna are very low. At the nominal received signal strength (-128 dBm) it is below the thermal noise floor of -111 dBm . Due to this fact, a GNSS receiver is susceptible to interference from nearby RF sources of any kind. Two cases can be distinguished:

- Out-of-band interference: Typically any kind of wireless communications system (e.g. LTE, GSM, CDMA, 3G, WLAN, Bluetooth, etc.) may emit its specified maximum transmit power in close proximity to the GNSS receiving antenna, especially if such a system is integrated with the GNSS receiver. Even at reasonable antenna selectivity, destructive power levels may reach the RF input of the GNSS receiver. Also, larger signal interferers may generate intermodulation products inside the GNSS receiver front-end that fall into the GNSS band and contribute to in-band interference.
- In-band interference: Although the GNSS band is kept free from intentional RF signal sources by radio-communications standards, many devices emit RF power into the GNSS band at levels much higher than the GNSS signal itself. One reason is that the frequency band above 1 GHz is not well regulated with regards to EMI, and even if permitted, signal levels are much higher than GNSS signal power. Notably, all types of digital equipment, like PCs, digital cameras, LCD screens, etc. tend to emit a broad frequency spectrum up to several GHz of frequency. Also wireless transmitters may generate spurious emissions that fall into GNSS band.

As an example, GSM uses power levels of up to 2W (+33 dBm). The absolute maximum power input at the RF input of the GNSS receiver can be +15 dBm. The GSM specification allows spurious emissions for GSM transmitters of up to 36 dBm, while the GNSS signal is less than -128 dBm. By simply comparing these numbers it is obvious that interference issues must be seriously considered in any design of a GNSS receiver. Different design goals may be achieved through different implementations:

- The primary focus is prevention of destruction of the receiver from large input signals. Here the GNSS performance under interference conditions is not important and suppression of the GNSS signal is permitted. It is sufficient to just observe the maximum RF power ratings of all the components in the RF input path.
- GNSS performance must be guaranteed even under interference conditions. In that case, not only the maximum power ratings of the components in the receive patch must be observed. Further, non-linear effects like gain compression, NF degradation (desensitization) and intermodulation must be analyzed.

☞ Pulsed interference with a low duty cycle like e.g. GSM may be destructive due to the high peak power levels.

4.2 In-band interference mitigation

With in-band interference, the signal frequency is very close to the GNSS frequency. Such interference signals are typically caused by harmonics from displays, micro-controller operation, bus systems, etc. Measures against in-band interference include:

- Maintaining a good grounding concept in the design
- Shielding
- Layout optimisation
- Low-pass filtering of noise sources, e.g. digital signal lines
- Remote placement of the GNSS antenna, far away from noise sources
- Adding a LTE, CDMA, GSM, WCDMA ,BT band-pass filter before antenna

4.3 Out-of-band interference

Out-of-band interference is caused by signal frequencies that are different from the GNSS carrier The main sources are wireless communication systems such as LTE, GSM, CDMA, WCDMA, WiFi, BT, etc.

Measures against out-of-band interference include maintaining a good grounding concept in the design and adding a GNSS band-pass filter into the antenna input line to the receiver.

For GSM applications, like a typical handset design, an isolation of approximately 20 dB can be reached with careful placement of the antennas. If this is insufficient, an additional SAW filter is required on the GNSS receiver input to block the remaining GSM transmitter energy.

5 Design

5.1 Pin assigment

The pin assignment of the ZED-F9P module is shown in Figure 37. The defined configuration of the PIOs is listed in Table 9.

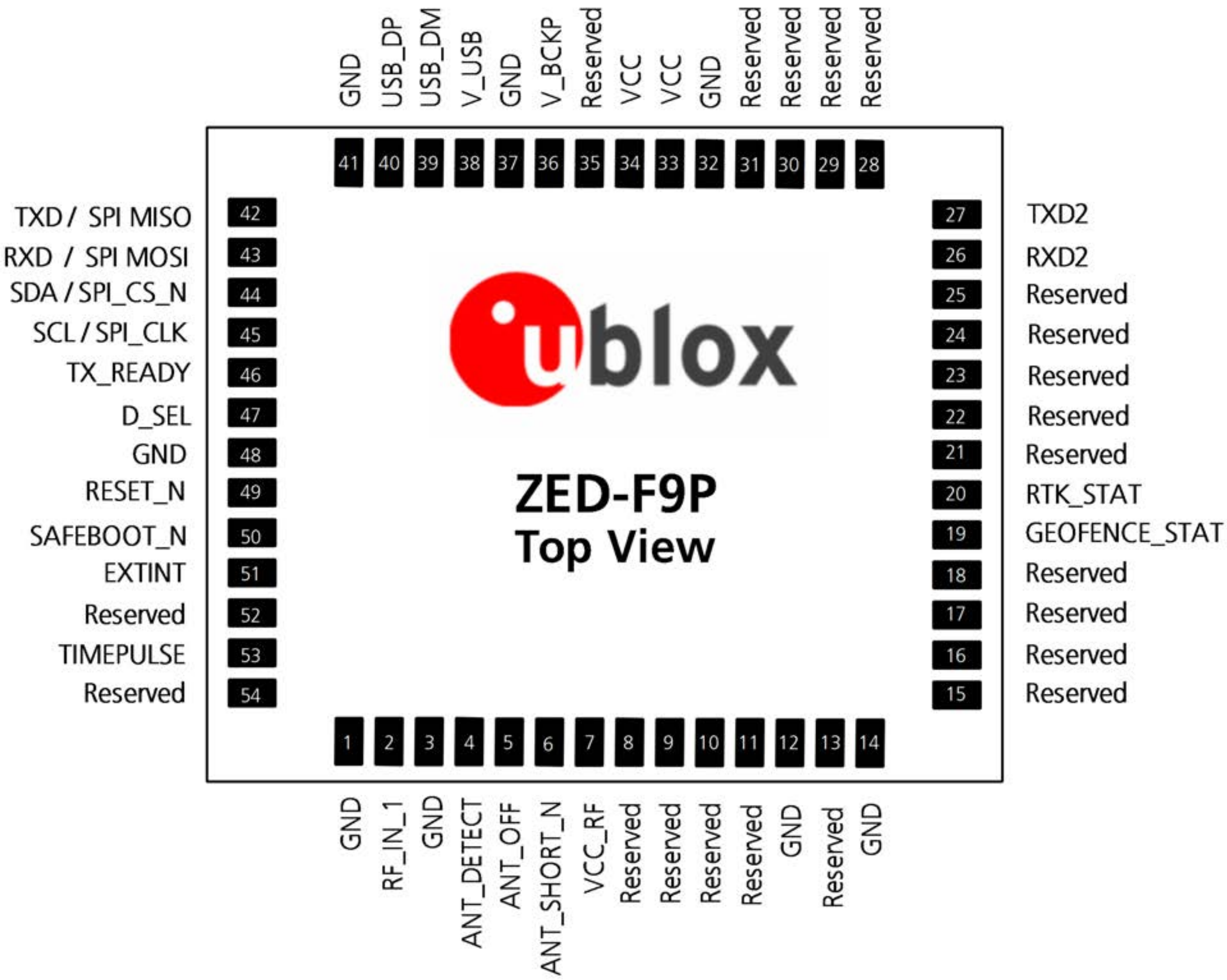


Figure 37: ZED-F9P pin assignment

Pin No	Name	I/O	Description
1	GND	-	Ground
2	RF_IN_1	I	RF input
3	GND	-	Ground
4	ANT_DETECT	I	Active antenna detect
5	ANT_OFF	O	External LNA disable
6	ANT_SHORT_N	I	Active antenna short detect
7	VCC_RF	O	Voltage for external LNA
8	Reserved	-	Reserved

Pin No	Name	I/O	Description
9	Reserved	-	Reserved
10	Reserved	-	Reserved
11	Reserved	-	Reserved
12	GND	-	Ground
13	Reserved	-	Reserved
14	GND	-	Ground
15	Reserved	-	Reserved
16	Reserved	-	Reserved
17	Reserved	-	Reserved
18	Reserved	-	Reserved
19	GEOFENCE_STAT	O	Geofence status, user defined
20	RTK_STAT	O	RTK status 0 – Fixed, blinking – receiving RTCM data, 1 – no corrections
21	Reserved	-	Reserved
22	Reserved	-	Reserved
23	Reserved	-	Reserved
24	Reserved	-	Reserved
25	Reserved	-	Reserved
26	RXD2	I	Correction UART input
27	TXD2	O	Correction UART output
28	Reserved	-	Reserved
29	Reserved	-	Reserved
30	Reserved	-	Reserved
31	Reserved	-	Reserved
32	GND	-	Ground
33	VCC	I	Voltage supply
34	VCC	I	Voltage supply
35	Reserved	-	Reserved
36	V_BCKUP	I	Backup supply voltage
37	GND	-	Ground
38	V_USB	I	USB supply
39	USB_DM	I/O	USB data
40	USB_DP	I/O	USB data
41	GND	-	Ground
42	TXD / SPI MISO	O	Host UART output if D_SEL = 1(or open). SPI MISO if D_SEL = 0
43	RXD / SPI MOSI	I	Host UART input if D_SEL = 1(or open). SPI MOSI if D_SEL = 0
44	SDA / SPI_CS_N	I/O	DDC Data if D_SEL = 1 (or open). SPI Chip Select if D_SEL = 0
45	SCL / SPI_CLK	I/O	DDC Clock if D_SEL = 1(or open). SPI Clock if D_SEL = 0
46	TX_READY	O	TX_Buffer full and ready for TX of data
47	D_SEL	I	Interface select for pins 42-45
48	GND	-	Ground
49	RESET_N	I	RESET_N
50	SAFEBOOT_N	I	SAFEBOOT_N (for future service, updates and reconfiguration, leave OPEN)
51	EXTINT	I	External Interrupt Pin
52	Reserved	-	Reserved

Pin No	Name	I/O	Description
53	TIMEPULSE	O	Time pulse
54	Reserved	-	Reserved

Table 9: ZED-F9P pin assigment

☞ USB is currently only made available for debugging purposes.

5.2 RF front-end circuit options

The first stages of the signal processing chain are crucial to the overall receiver performance. Also, in many applications an input connector may be used to receive the RF-input. This can provide a conduction path for harmful or even destructive electrical signals and hence the RF input needs to be protected accordingly.

If a combined GNSS L1 + L2 + L band (NEO-D9) RF system is to be used, a suitable band power divider should be used.

Separate RF IN system

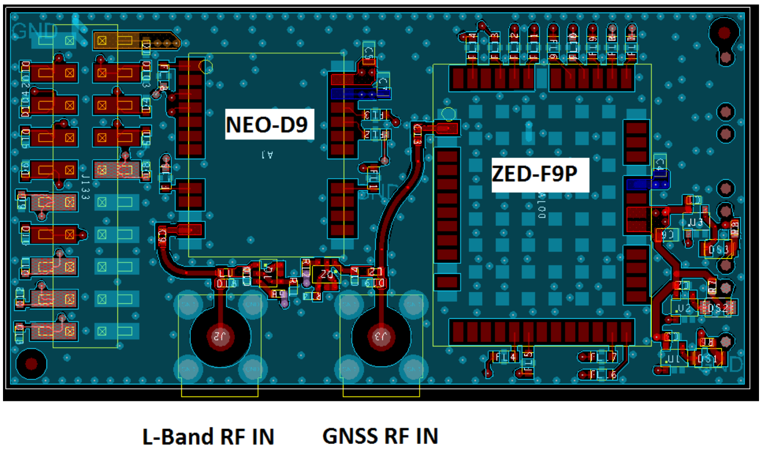


Figure 38: ZED-F9P and NEO-D9 RF IN

☞ For a separate RF IN system the L-Band antenna might be separate from the GNSS antenna. The L-Band antenna must meet the signal specification for the NEO-D9 module being used.

Combined GNSS and L-Band RF IN

If the antenna is a combined GNSS and L-band corrections unit with a single RF feed there are several options based on RF competence and operating temperature range of target application.

An equal power splitter can be implemented to split the power and frequency range equally between the ZED-F9P and the NEO-D9.

This can be achieved by using discrete Power splitter devices that are in a single SMD package.

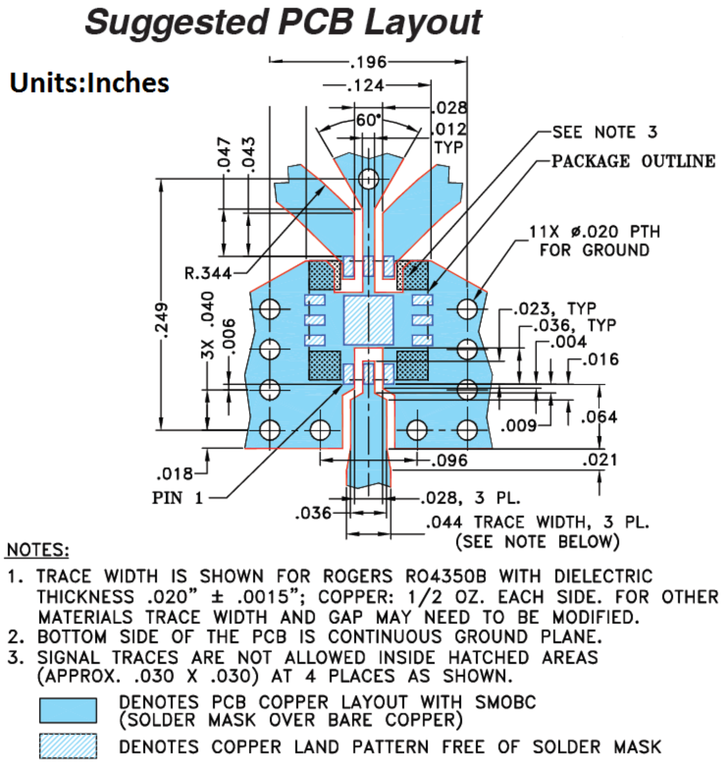


Figure 39: SMD splitter layout

Suitable band splitter components for +85 Degrees Celcius maximum temperatures are shown below:

Figure 40: Minicircuits GP2S+

Figure 41: Minicircuits SCN-3-16+

PCB trace Power Splitter

For operating temperatures of maximum +125 Degrees Celcius suitable band power dividers might be difficult to find. In that case a PCB trace power divider might need to be designed. This is not a simple task and requires RF simulation and RF design expertise. It is important that the PCB trace design uses a minimum amount of L/C passive components as these can cause dramatic variation over temperature and component tolerance. Montecarlo 250 simulations and 5% (Gaussian) component tolerances need to be run to confirm the affects of these L/C components.

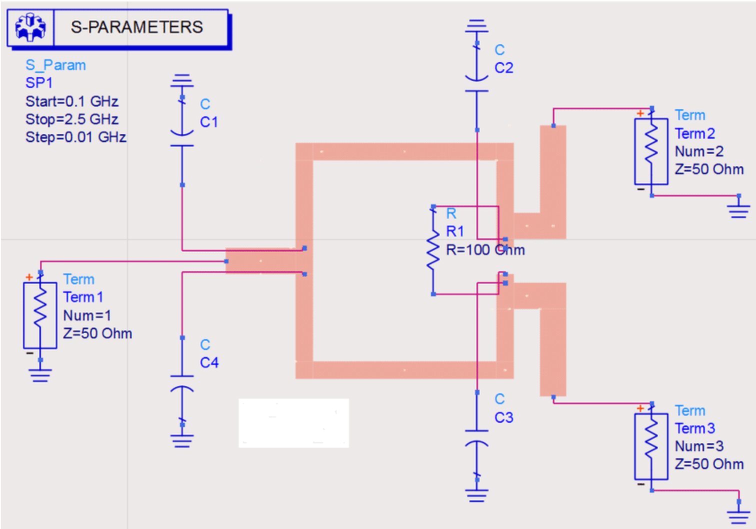


Figure 42: Wilkinson Divider

Additional points on the RF input

If an additional LNA protection filter shall be used its bandwidth has also to be increased for combined GNSS L1 + L2 + L band signals.

What is the expected quality of the signal source (antenna)?

- What is the external active antenna signal power?
- What is the bandwidth and filtering of the external active antenna?

Are destructive RF power levels expected to reach the RF-input? Is interference from wireless transmitters expected?

- What are the characteristics of these signals (duty cycle, frequency range, power range, spectral purity)?
- What is the expected GNSS performance under interference conditions?

Is there a risk of RF-input exposure to excessive ESD stress?

- In the field: Is the antenna connector accessible by the user?
- PCB / system assembly: Is there risk that statically charged parts (e.g. patch antennas) may be discharged through the RF-input?

Is there a risk of RF-input exposure to excessive ESD stress?

- In the field: Is the antenna connector accessible by the user?
- PCB / system assembly: Is there risk that statically charged parts (e.g. patch antennas) may be discharged through the RF-input?

The following subsections provide several options addressing the various questions above:

☞ In some applications, such as GSM transceivers, interference signals may exceed the maximum power rating of the LNA_IN input. To avoid device destruction use of external input protection is mandatory.

☞ During assembly of end-user devices which contain passive patch antennas, an ESD discharge may occur during production when pre-charged antennas are soldered to the GNSS receiver board. In such cases, use of external protection in front of LNA_IN is mandatory to avoid device destruction.

ESD discharge cannot be avoided during assembly and / or field use. Note also that SAW filters are susceptible to ESD damage.

☞ ESD discharge into the RF input cannot always be avoided during assembly or field use with this Circuit. To provide additional robustness an ESD protection diode, can be placed at LNA_IN to GND.

5.3 ZED-F9P minimal design

The minimal electrical circuit for ZED-F9P operation using the UART1 interface is shown below

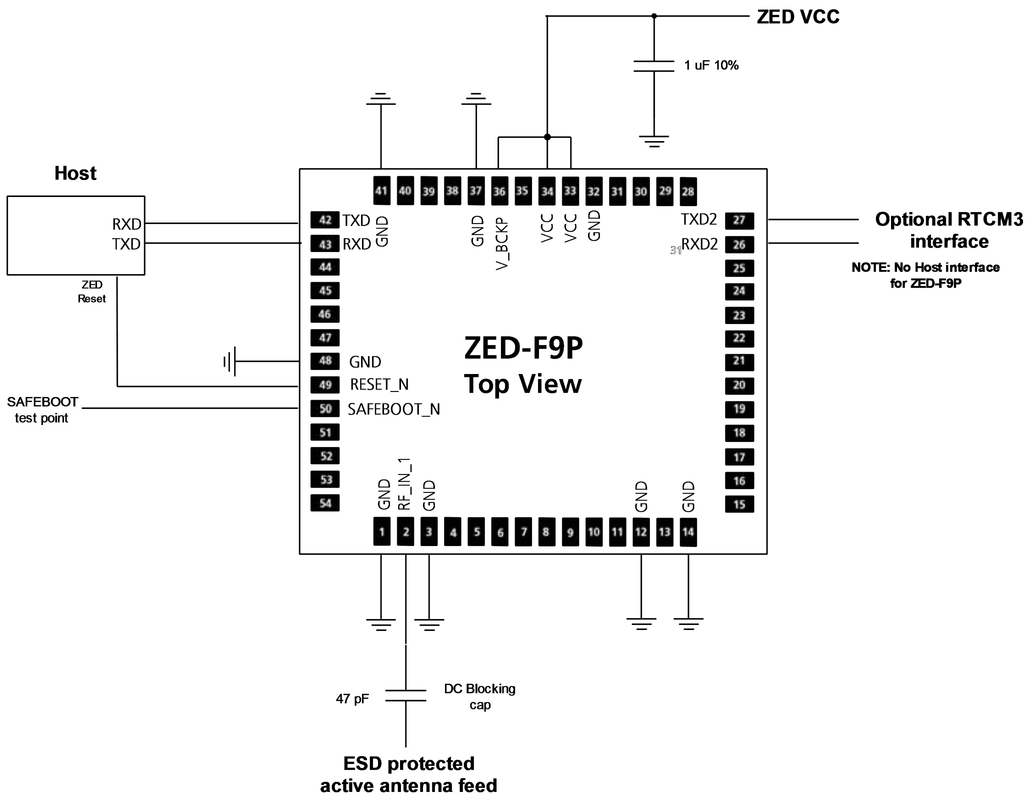


Figure 43: Minimal ZED-F9P design

The UART1 interface that is connected to the Host will usually also have the RTCM3 messages required for RTK operation transferred on it. The optional UART2 interface can only be used for RTCM3 messages and has no Host interface capabilities. This interface is primarily intended for connection to a satellite correction receiver.

5.4 ZED-F9P antenna bias

Active antennas have an integrated low-noise amplifier. Active antennas require a power supply that will contribute to the total GNSS system power consumption budget with additional 5 to 20 mA typically. If the customers do not want to make use of the Antenna Supervisor function and the supply voltage of the ZED-F9P module matches the supply voltage of the antenna (e.g. 3.0 V), they can use the filtered supply voltage VCC_RF output to supply the antenna. However a 10 Ohm current limiting resistor is required to prevent against short circuits destroying the BIAS-T inductor.

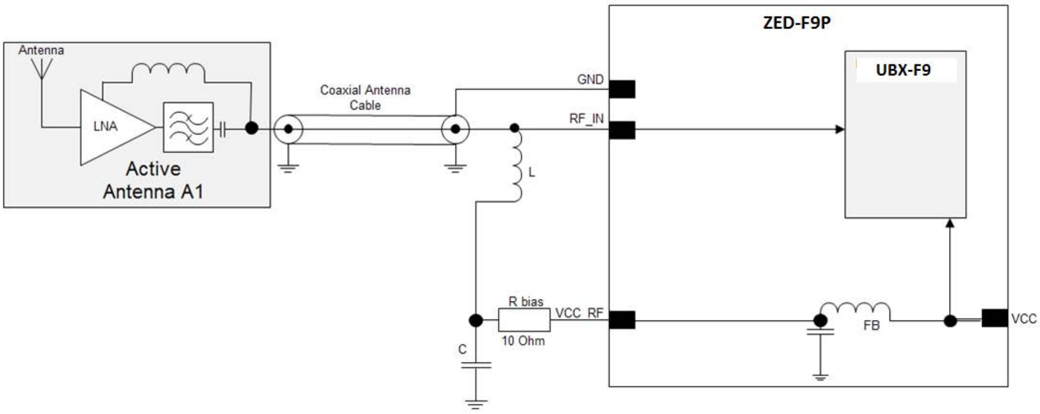


Figure 44: ZED-F9P VCC_RF antenna bias

If the VCC_RF voltage does not match with the supply voltage of the active antenna, use a filtered external supply.

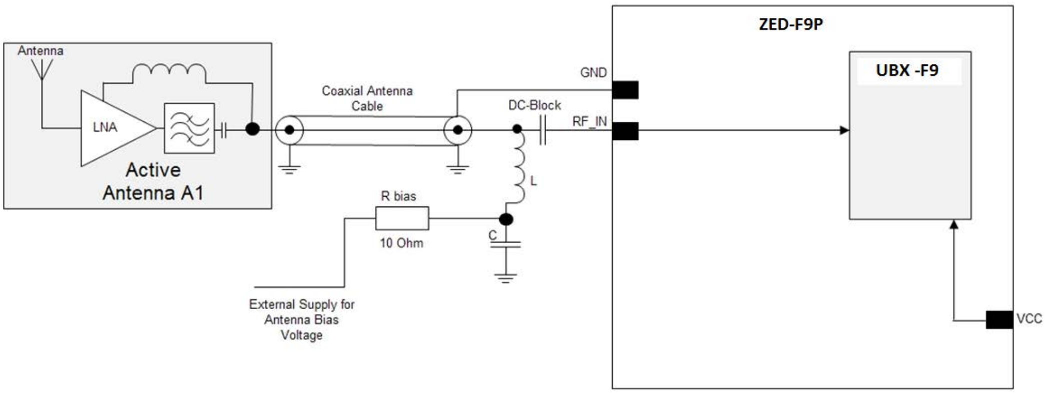


Figure 45: ZED-F9P external voltage antenna bias

The recommended circuit design for the active antenna bias using an external voltage and current limiting circuit is shown below. This also includes ESD protection that must be implemented.

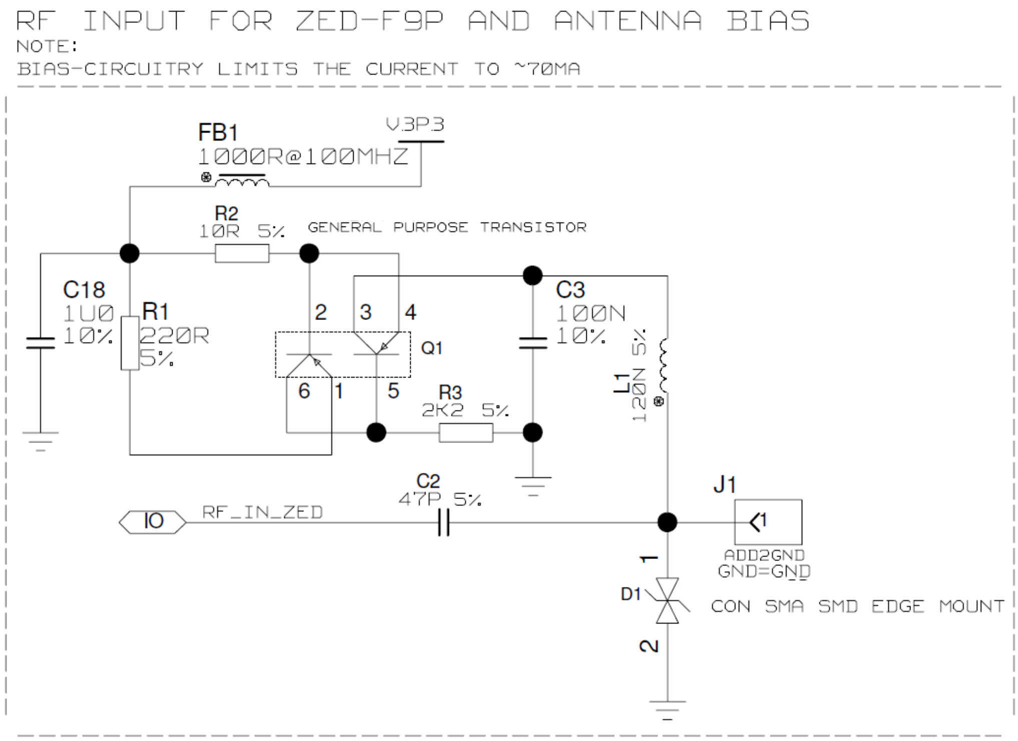


Figure 46: ZED-F9P antenna bias

5.5 Layout

This section details layout and placement requirements of the ZED-F9P high precision receiver.

5.5.1 Placement

GNSS signals at the surface of the Earth are about 19 dB below the thermal noise floor. A very important factor in achieving maximum GNSS performance is the placement of the receiver on the PCB. The Placement used may affect RF signal loss from antenna to receiver input and enable interference into the sensitive parts of the receiver chain, including the antenna itself. When defining a GNSS receiver layout, the placement of the antenna with respect to the receiver, as well as grounding, shielding and interference from other digital devices are crucial issues and need to be considered very carefully.

Signal loss on the RF connection from antenna to receiver input must be minimized as much as possible. Hence, the connection to the antenna must be kept as short as possible.

Make sure that RF critical circuits are clearly separated from any other digital circuits on the system board. To achieve this, position the receiver digital part towards your digital section of the system PCB and have the RF section and antenna placed as far as possible away from the other digital circuits on the board.

A proper GND concept shall be followed: The RF section should not be subject to noisy digital supply currents running through its GND plane.

Care must also be exercised with placing the receiver in proximity to circuitry that can emit heat. The RF part of the receiver is very sensitive to temperature and sudden changes can have an adverse impact on performance.

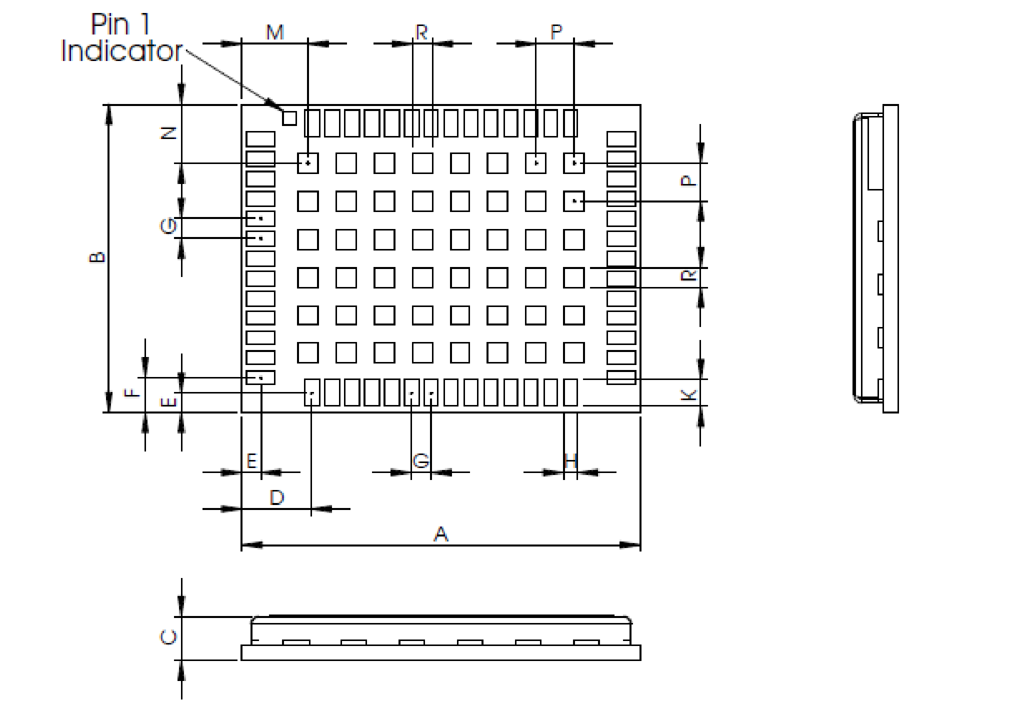
⚠ **Attention** The TCXO of a GNSS receiver is a temperature sensitive device. Avoid high temperature drift and air convection.

5.5.2 Package footprint, copper and solder mask

Copper and solder mask dimensioning recommendations for the ZED-F9P high precision receiver packages are provided in this section. For all packages, the yellow color shows the copper (etch) dimensions, the green color shows the solder mask opening dimensions and the red circles indicate vias. Some PCB manufacturers prefer to adapt solder mask openings to their process tolerances. The recommendations given in this section provide the nominal openings not including such additional tolerances.

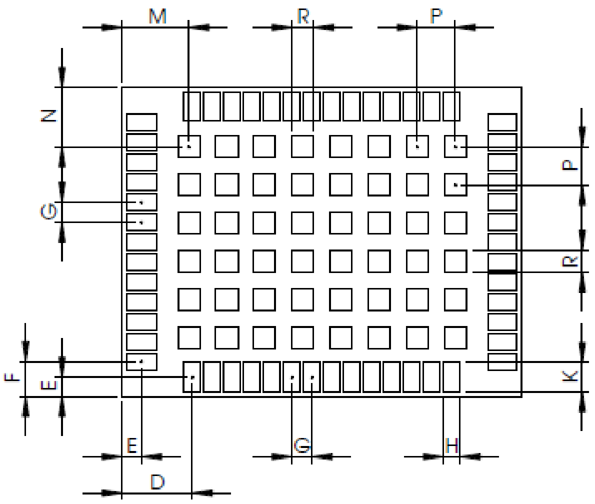
Paste mask recommendations are not provided as these are usually specifically related to the solder paste in use as well as the particular reflow process.

Units below are in mm.



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	21.80	22.00	22.20
B	16.80	17.00	17.20
C	2.20	2.40	2.60
D	tbd	3.85	tbd
E	tbd	1.05	tbd
F	tbd	1.90	tbd
G	tbd	1.10	tbd
H	tbd	0.80	tbd
K	tbd	1.50	tbd
M	tbd	3.65	tbd
N	tbd	3.25	tbd
P	tbd	2.10	tbd
R	tbd	1.10	tbd
Weight		tbd	

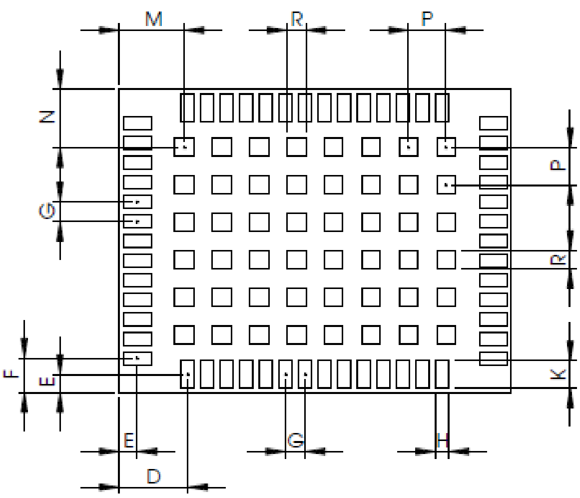
Figure 47: ZED-F9P LGA mechanical dimensions



Soldermask

Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
D		3.85	
E		1.05	
F		1.90	
G		1.10	
H		0.90	
K		1.60	
M		3.65	
N		3.25	
P		2.10	
R		1.20	

Figure 48: ZED-F9P LGA Solder mask dimensions



Pastemask

Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
D		3.85	
E		1.00	
F		1.90	
G		1.10	
H		0.75	
K		1.55	
M		3.65	
N		3.25	
P		2.10	
R		1.05	

Figure 49: ZED-F9P LGA Paste mask dimensions

5.6 Layout Guidance

Presented layout guidance reduces the risk of performance issues at design level with the ZED-F9P high precision receiver.

5.6.1 RF In trace

The RF In trace has to work in the combined GNSS L1 + L2 signal band. This requires the center frequency for a 50 Ohm trace to be calculated midband of the GNSS receiver bandwidth. The

Bandwidth of the Multi-band GNSS receiver is from 1197 MHz to 1608 MHz. The mid band of this would be 1402 MHz. We then calculate the micrsostrip trace width for 50 Ohm at 1402 MHz.

For FR-4 PCB material with a Dielectric permativity of for example 4.7 we can calculate the trace width at 1402 MHz for 50 Ohm impedance. For example Dielectric height of the PCB = 1 mm. Therefore the trace width would be 1.82 mm.

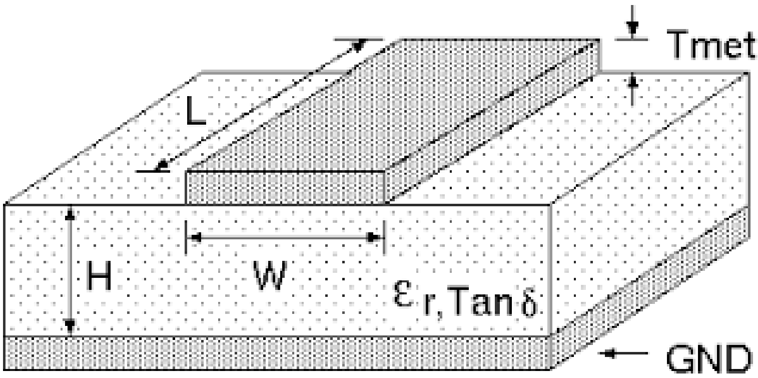


Figure 50: Microstrip trace width

Make sure that RF critical circuits are clearly separated from any other digital circuits on the system board. To achieve this, position the receiver digital part towards your digital section of the system PCB and have the RF section and antenna placed as far as possible away from the other digital circuits on the board.

A proper GND concept shall be followed: The RF section should not be subject to noisy digital supply currents running through its GND plane.

Care must also be exercised with placing the receiver in proximity to circuitry that can emit heat. The RF part of the receiver is very sensitive to temperature and sudden changes can have an adverse impact on performance.

Attention The TCXO of a GNSS receiver is a temperature sensitive device. Avoid high temperature drift and air convection.

The RF trace must be shielded by vias to Ground along the entire length of the trace and the ZED-F9P high precision receiver RF_IN pad should be surrounded by vias as shown in the figure below.

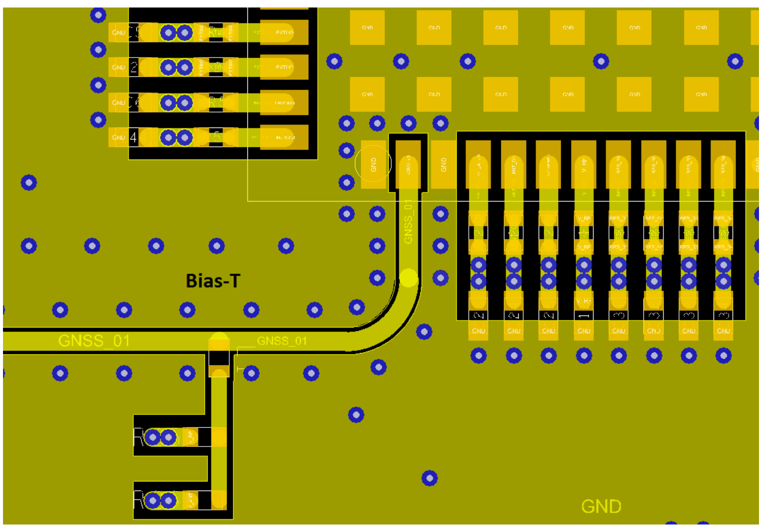


Figure 51: RF input trace

The RF in trace on the Top layer should be referenced to Layer 2 (Ground). However the ZED-F9P high precision receiver RF IN pad should have a slot surrounding it in the layer 2 Ground layer as shown below.

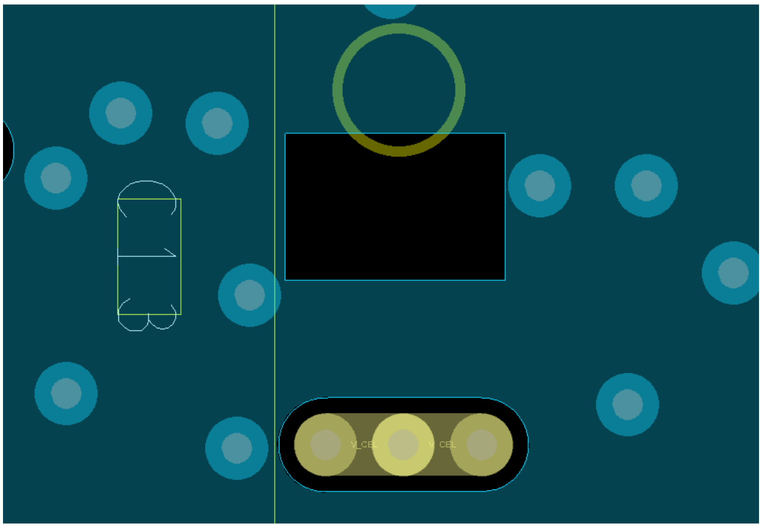


Figure 52: Layer 2 Ground

5.6.2 Vias for the ground pads

The ground pads under the ZED-F9P high precision receiver need to be grounded with vias to the lower ground layer of the PCB. A solid ground layer fill on the Top layer of the PCB is recommended. This is shown in the figure below.

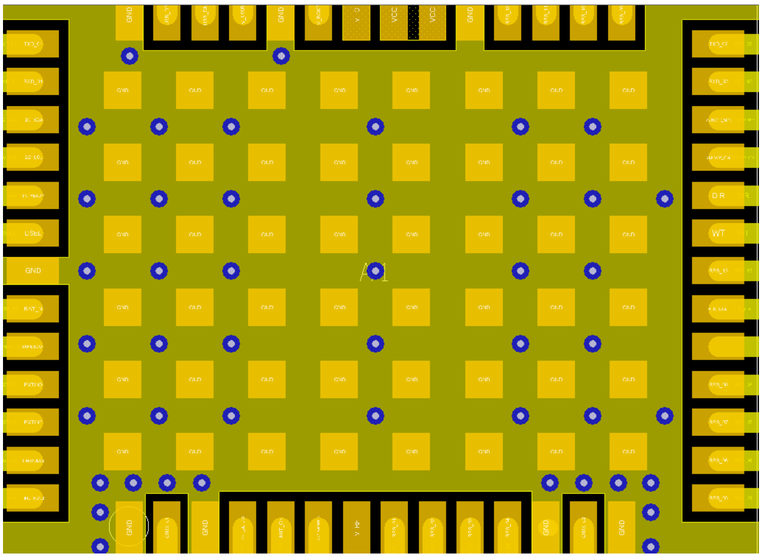


Figure 53: Top layer fill and vias

5.6.3 VCC pads

The VCC pads for the ZED-F9P high precision receiver need to be as low an impedance as possible with large vias to the lower Power layer of the PCB. The VCC pads need a large combined pad and the de-coupling capacitors must be placed as close as possible. This is shown in the figure below.

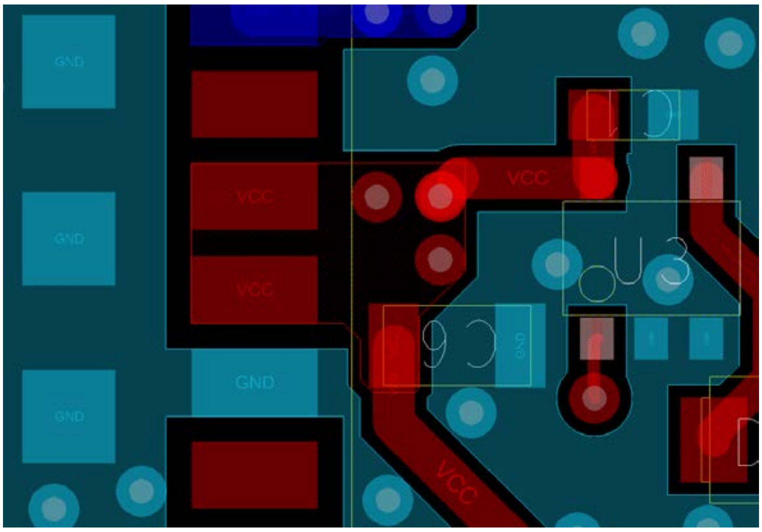


Figure 54: VCC pads

5.6.4 PCB stackup

A typical PCB layer stackup for the ZED-F9P high precision receiver is shown below:

	Subclass Name	Type	Material	Thickness (UM)	Conductivity (mho/cm)	Dielectric Constant	Loss Tangent
1		SURFACE	AIR			1	0
2	TOP	CONDUCTOR	COPPER	35	595900	4.5	0
3		DIELECTRIC	FR-4	360	0	4.5	0.035
4	L2	CONDUCTOR	COPPER	18	595900	4.5	0.035
5		DIELECTRIC	FR-4	190	0	4.5	0.035
6	L3	CONDUCTOR	COPPER	18	595900	4.5	0.035
7		DIELECTRIC	FR-4	360	0	4.5	0.035
8	L4	CONDUCTOR	COPPER	18	595900	4.5	0.035
9		DIELECTRIC	FR-4	190	0	4.5	0.035
10	L5	CONDUCTOR	COPPER	18	595900	4.5	0.035
11		DIELECTRIC	FR-4	360	0	4.5	0.035
12	BOTTOM	CONDUCTOR	COPPER	35	595900	4.5	0
13		SURFACE	AIR			1	0

Figure 55: PCB Stackup

6 Product handling

6.1 Soldering

Soldering Paste

Use of “No Clean” soldering paste is highly recommended, as it does not require cleaning after the soldering process has taken place. The paste listed in the example below meets these criteria.

- Soldering Paste: OM338 SAC405 / Nr.143714 (Cookson Electronics)
- Alloy specification: Sn 95.5/ Ag 4/ Cu 0.5 (95.5% Tin/ 4% Silver/ 0.5% Copper)
- Melting Temperature: 217 °C
- Stencil Thickness: The exact geometry, distances, stencil thicknesses and solder paste volumes must be adapted to the specific production processes (e.g. soldering) of the customer.

Reflow soldering

A convection type-soldering oven is highly recommended over the infrared type radiation oven. Convection heated ovens allow precise control of the temperature, and all parts will heat up evenly, regardless of material properties, thickness of components and surface color.

As a reference, see the “IPC-7530 Guidelines for temperature profiling for mass soldering (reflow and wave) processes”, published in 2001.

Preheat phase

During the initial heating of component leads and balls, residual humidity will be dried out. Note that this preheat phase will not replace prior baking procedures.

- Temperature rise rate: max. 3 °C/s. If the temperature rise is too rapid in the preheat phase it may cause excessive slumping.
- Time: 60 – 120 s. If the preheat is insufficient, rather large solder balls tend to be generated. Conversely, if performed excessively, fine balls and large balls will be generated in clusters.
- End Temperature: 150 – 200 °C. If the temperature is too low, non-melting tends to be caused in areas containing large heat capacity.

Heating - Reflow Phase

The temperature rises above the liquidus temperature of 217°C. Avoid a sudden rise in temperature as the slump of the paste could become worse.

- Limit time above 217 °C liquidus temperature: 40 – 60 s
- Peak reflow temperature: 245 °C

Cooling Phase

A controlled cooling avoids negative metallurgical effects (solder becomes more brittle) of the solder and possible mechanical tensions in the products. Controlled cooling helps to achieve bright solder fillets with a good shape and low contact angle.

- Temperature fall rate: max 4 °C/s

☞ To avoid falling off, the modules should be placed on the topside of the motherboard during soldering

The final soldering temperature chosen at the factory depends on additional external factors like choice of soldering paste, size, thickness and properties of the base board, etc. Exceeding the maximum soldering temperature in the recommended soldering profile may permanently damage the module.

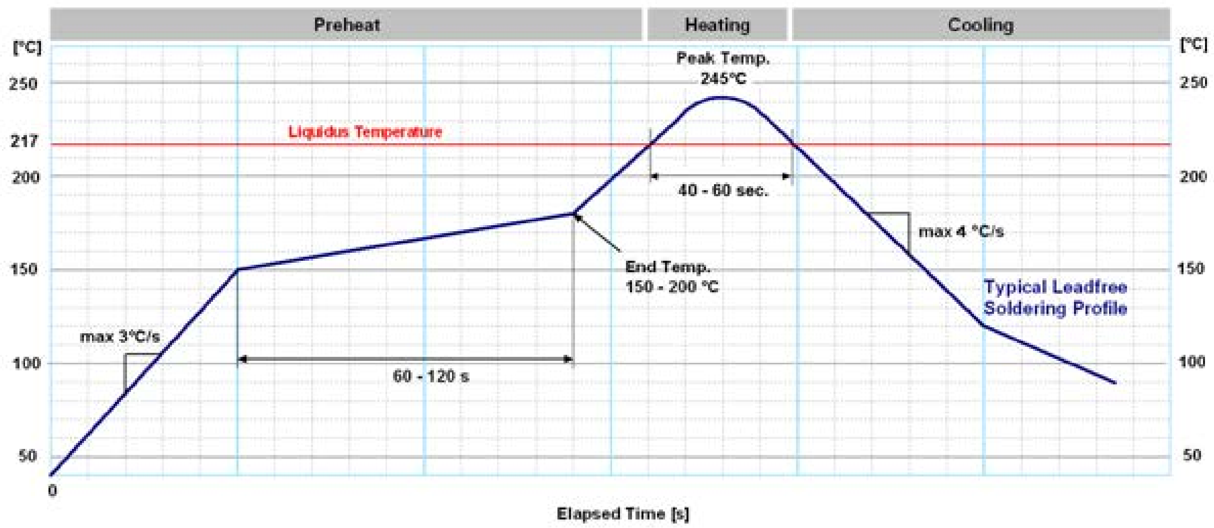


Figure 56: Soldering Profile

☞ Modules **must not** be soldered with a damp heat process.

Optical inspection

After soldering the module, consider an optical inspection step to check whether:

- Cleaning with water will lead to capillary effects where water is absorbed in the gap between the baseboard and the module. The combination of residues of soldering flux and encapsulated water leads to short circuits or resistor-like interconnections between neighboring pads.
- Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into the two housings, areas that are not accessible for post-wash inspections. The solvent will also damage the sticker and the ink-jet printed text.
- Ultrasonic cleaning will permanently damage the module, in particular the quartz oscillators.

The best approach is to use a "No Clean" soldering paste and eliminate the cleaning step after the soldering.

Repeated reflow soldering

Only single reflow soldering processes are recommended for boards populated with modules. Modules should not be submitted to two reflow cycles on a board populated with components on both sides in order to avoid upside down orientation during the second reflow cycle. In this case, the module should always be placed on that side of the board, which is submitted into the last reflow cycle. The reason for this (besides others) is the risk of the module falling off due to the significantly higher weight in relation to other components.

Two reflow cycles can be considered by excluding the above described upside down scenario and taking into account the rework conditions described in this section.

☞ Repeated reflow soldering processes and soldering the module upside down are not recommended.

Wave soldering

Base boards with combined through-hole technology (THT) components and surface-mount technology (SMT) devices require wave soldering to solder the THT components. Only a single wave soldering process is encouraged for boards populated with modules.

Rework

The module can be unsoldered from the baseboard using a hot air gun. When using a hot air gun for unsoldering the module, a maximum of one reflow cycle is allowed. In general, we do not recommend using a hot air gun because this is an uncontrolled process and might damage the module.

⚠ **Attention** Use of a hot air gun can lead to overheating and severely damage the module. Always avoid overheating the module.

After the module is removed, clean the pads before re-applying solder paste, placing and reflow soldering a new module.

⚠ **Attention** Never attempt a rework on the module itself, e.g. replacing individual components. Such actions immediately terminate the warranty.

Conformal coating

Certain applications employ a conformal coating of the PCB using HumiSeal® or other related coating products. These materials affect the HF properties of the GNSS module and it is important to prevent them from flowing into the module. The RF shields do not provide 100% protection for the module from coating liquids with low viscosity; therefore, care is required in applying the coating.

☞ Conformal Coating of the module will void the warranty.

Casting

If casting is required, use viscose or another type of silicon pottant. The OEM is strongly advised to qualify such processes in combination with the module before implementing this in the production.

☞ Casting will void the warranty.

Grounding metal covers

Attempts to improve grounding by soldering ground cables, wick or other forms of metal strips directly onto the EMI covers is done at the customer's own risk. The numerous ground pins should be sufficient to provide optimum immunity to interferences and noise.

☞ u-blox makes no warranty for damages to the module caused by soldering metal cables or any other forms of metal strips directly onto the EMI covers.

Use of ultrasonic processes

Some components on the module are sensitive to Ultrasonic Waves. Use of any Ultrasonic Processes (cleaning, welding etc.) may cause damage to the GNSS Receiver.

☞ u-blox offers no warranty against damages to the module caused by any Ultrasonic Processes.

6.2 Tapes

The Figure 57 shows the feed direction and illustrates the orientation of the ZED-F9P high precision receivers on the tape:

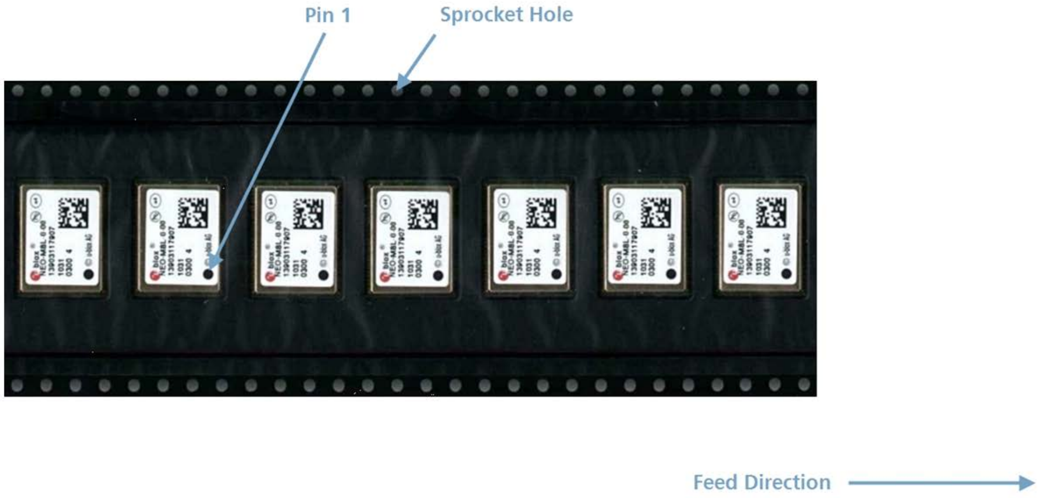


Figure 57: Orientation of ZED-F9P high precision receivers on the tape

The dimensions of the tapes for ZED-F9P high precision receivers are specified in Figure 58 (measurements in mm).

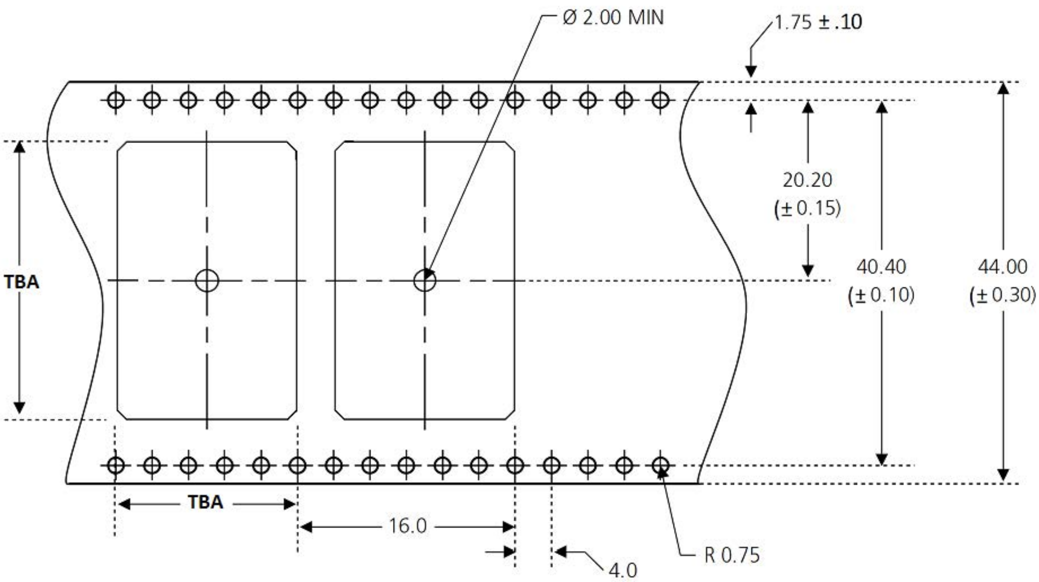


Figure 58: ZED-F9P tape dimensions (mm)

6.3 Reels

The ZED-F9P high precision receiver GNSS modules are deliverable in quantities of 250 pieces on a reel. The ZED-F9P high precision receiver receivers are shipped on Reel Type B, as specified in the u-blox Package Information Guide. Please see the *u-blox Package Information Guide* [3].

6.4 Moisture Sensitivity Levels

The Moisture Sensitivity Level (MSL) for ZED-F9P high precision receivers is specified in the table below.

Package	MSL Level
LGA	4

Table 10: MSL Level

☞ For MSL standard see IPC/JEDEC J-STD-020, which can be downloaded from www.jedec.org.

☞ For more information regarding moisture sensitivity levels, labeling, storage and drying, see the *u-blox Package Information Guide* [3].

7 Antenna

☞ u-blox highlights that the use of an active antenna is a pre-requisite for meeting the stated RTK performance

☞ A suitable ground plane is required for the antenna to achieve good RTK performance.

☞ Location of the antenna is critical for reaching stated and good RTK performance, not suitable for under vehicle dash location, rear view mirror location, etc.

L1 + L2 active antenna required specifications

Parameter	**Specification**	
Antenna Type		Active antenna
Active Antenna Recommendations	Typical gain	30 dB
	Maximum gain	40 dB
	Maximum noise figure	2 dB
L1 band antenna gain[1]	1559 - 1606 MHz: 3 dBic typ.	
L2 band antenna gain[2]	1197 - 1249 MHz: 2 dBic typ.	
Polarization	RHCP	
Axial Ratio	2 dB max at Zenith	
Phase Center Variation	<10 mm over Elevation/Azimuth	
Group Delay Variation in-band[3]	10 ns max @ each GNSS system bandwidth. Note: Inter-signal requirement 50 ns max.	
EMI immunity out-of-band[4]	30 V/m	
Out-of-band [5] Rejection	40 dB typ	
ESD Circuit Protection	15 kV human body model air discharge	

Table 11: Antenna Specifications for ZED-F9P modules

The antenna system should include filtering to ensure adequate protection from nearby transmitters. Care should be taken in the selection of antennas placed close to cellular or WiFi transmitting antennas.

7.1 Stacked patch antenna

The typical L1 + L2 antenna will be a stacked patch antenna design. There will be a discrete L1 patch on top of a L2 patch.

1 Measured with a Ground Plane d=150 mm

2 Measured with a Ground Plane d=150 mm

3 GNSS system bandwidths: 1559... 1563 MHz; 1573... 1578 MHz; 1598... 1606 MHz; 1192... 1212 MHz; 1197... 1217 MHz; 1223... 1231 MHz; 1242... 1249 MHz

4 Exception L1 and L2 bands +/- 200 MHz, emphasis on cellular bands

5 GNSS system bandwidths: 1559... 1563 MHz; 1573... 1578 MHz; 1598... 1606 MHz; 1192... 1212 MHz; 1197... 1217 MHz; 1223... 1231 MHz; 1242... 1249 MHz

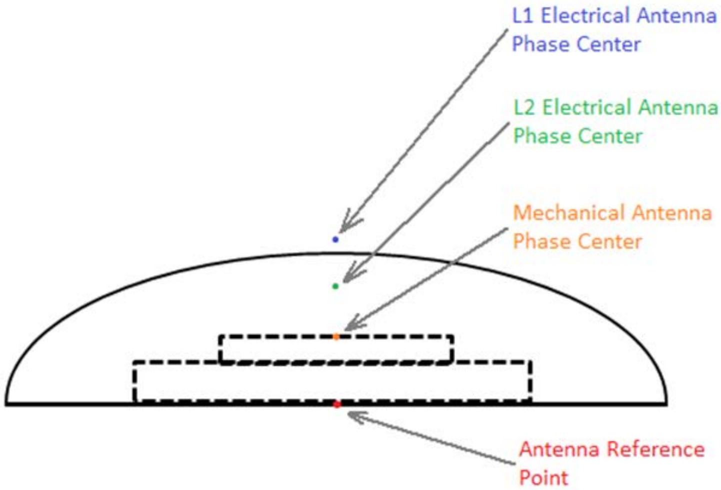


Figure 59: Stacked patch antenna

It is important to note that the absolute position of the antenna placement needs to be calculated from the L1/L2 phase-variation. The L1 and L2 patch phase centers must vary to a minimum. The final Antenna Reference point or ARP is what is then used to calculate the actual precise antenna position.

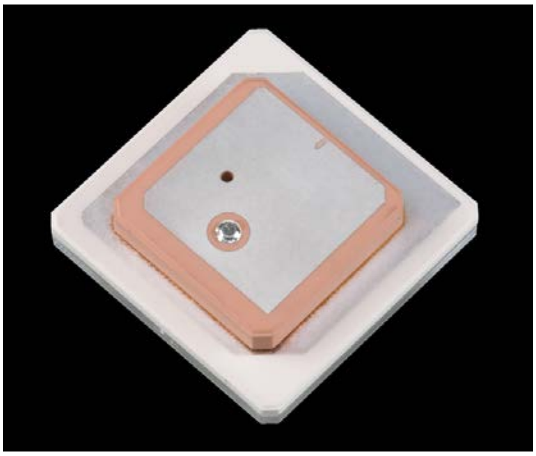


Figure 60: Ceramic Stack

If the antenna is to be used in an automotive application in mass production. The final placement of the antenna will affect the Phase center variation, the antenna ground plane size and shape and the antenna location to other bodies or structures will cause offsets. The final Phase center variation calibration will need to be done on the final vehicle with the antenna in its final location. If the phase variation of a specific antenna is repeatable between samples, the Phase center variation can be calibrated succesfully.

The absolute best performance will be obtained with the antenna in the center of the roof and not tilted at any large angle. However the placement of automotive antenna in a mass production vehicle will probably be compromised.

The antenna cannot be placed under a dashboard, in a rear view mirror or on the rear parcel shelf. It needs to have very good signal levels and the wide as possible view of the sky.

Low cost L1 + L2 stacked patch antenna must have a minimum band pass performance from their patch elements and the required internal SAW filtering. An example of the actual measured Band pass characteristics of a low cost L1 + L2 antenna is shown below.

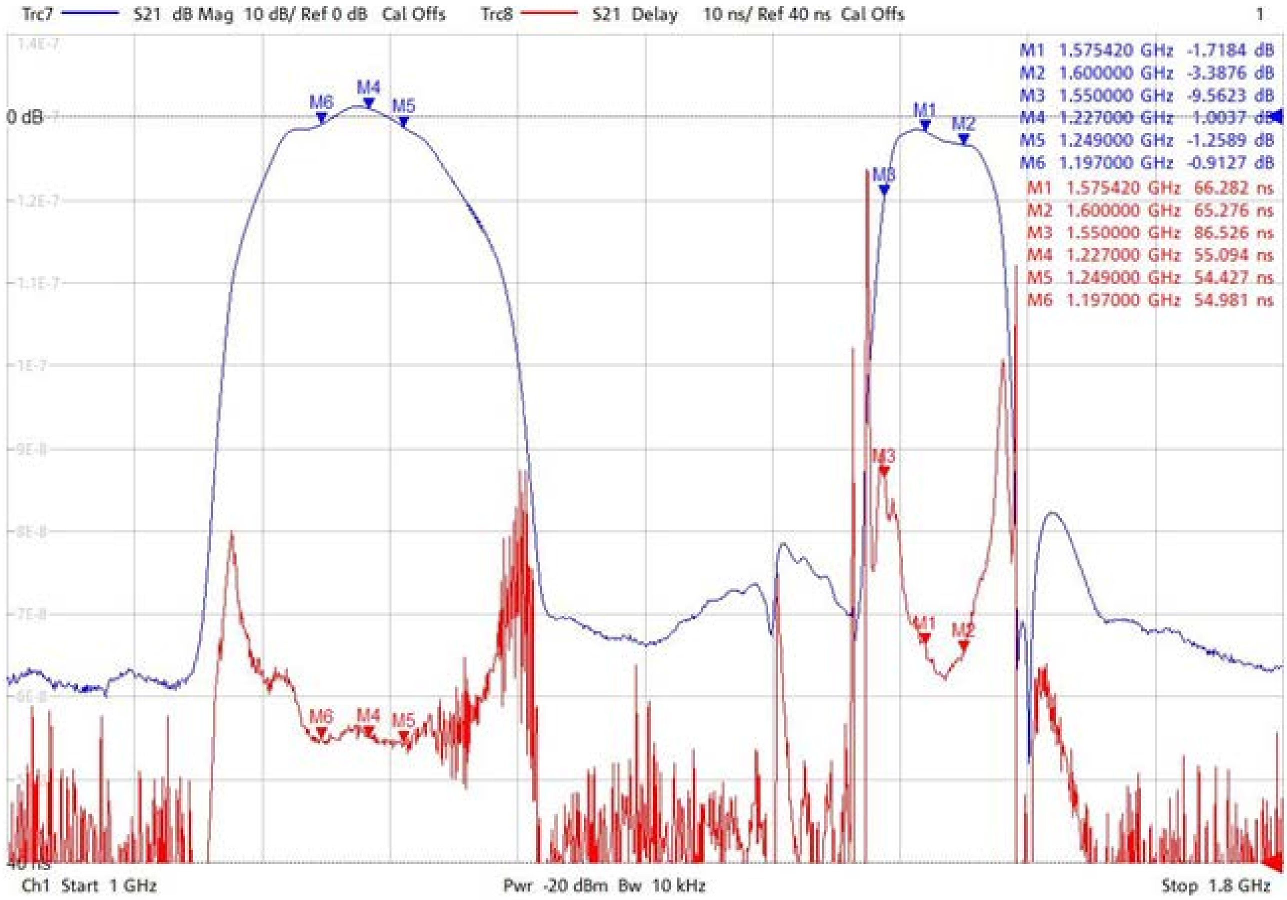


Figure 61: Low cost antenna Band characteristics

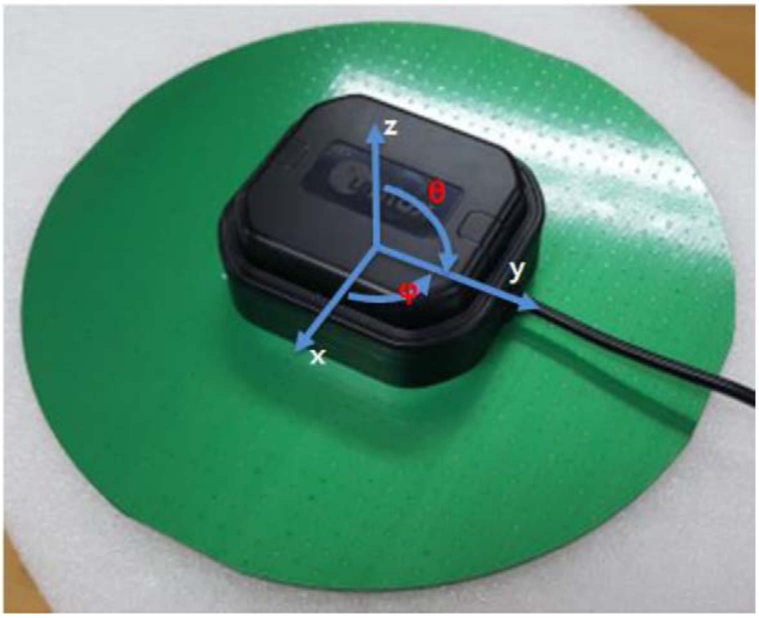


Figure 62: u-blox low cost RTK antenna

8 Related documents

1. ZED-F9P Data sheet, Docu. No. UBX-17051259
2. ZED-F9P Interface Description, Docu. No. UBX-18010853
3. u-blox Package Information Guide, Doc. No. UBX-14001652

☞ For regular updates to u-blox documentation and to receive product change notifications please register on our homepage (http://www.u-blox.com).

9 Revision history

Revision	Date	Name	Status / Comments
R01	22-May-2018	ghun	Objective Specification

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